# ARTICLE VIII.

## ON THE HYDROLOGY OF THE BASIN OF THE RIVER SAINT LAWRENCE.

BY THOMAS EVANS BLACKWELL, M.I.C.E.

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### INTRODUCTION.

THE subject of the following paper was suggested to the author, some four years since, while in company with the late lamented President, Sir William Cubitt, and the late Mr. J. K. Brunel, Vice-President of the Institution of Civil Engineers.

In accepting the proposal that he would prepare a paper originally intended for this Institution, respecting the Hydrology of part of British North America, the author had but a very limited view of the extent to which its ramifications would be likely to lead him. And at that time, too, there was very little prospect, from the nature of his occupations, of his being able to perform, to any adequate degree, a promise made with the intention of fulfilling it at an early period.

Still the subject was always an interesting one, and its study was aided to a certain extent by business which led him from time to time to make comparisons between the two great modes of inland communication, and this brought him in contact with individuals and afforded him knowledge of a number of circumstances which he felt would be interesting matter for a communication, even if they did not always represent subjects of a purely engineering character.

Materials for a large portion of the information which it has been his endeavor to digest to a presentable form, have been for the most part collected during a period of repose, that was necessary for the restoration of health, broken down for a time by unusual labor. In collecting and now reviewing these materials, the author has experienced the more relief, finding in it a return to former modes and subjects of thought. He is quite aware that much of the material, as well as the reflections thereon, may still have a crude and imperfect form; he trusts, however, to the leniency of critics, as he offers these remarks in good faith, and in the belief that the subject will be interesting especially at this period, seeing that a large portion of the inland waters of that part of North America now under consideration is to be viewed as common to both the British and American nations.

The traffic during the year 1861, has been affected by a number of circumstances, the chief of which are to be found in the unhappy differences which have paralyzed or blockaded all trading operations south of Pennsylvania; and these have had the effect of diverting into fewer channels the produce of a most abundant harvest, while favorable prices have likewise prevailed in the European markets, causing a great increase to the trade of the St. Lawrence.

## TOPOGRAPHY.

The hydrographical basin of the St. Lawrence is divisible by geographical lines and geographical features into six basins. *The first* embraces the Gulf and the lower river as high as Three Rivers, and includes the tidal estuary of the Saguenay as high as Chicontimi, seventy miles above its mouth.

*The second* is the basin of the St. Lawrence proper, embracing the river between Three Rivers and the Thousand Islands, a distance of two hundred miles; together with the Ottawa River, between Montreal and the Lac des Chats, a distance of one hundred and twenty miles; the St. Maurice, from its mouth to the entrance of the mountains, thirty miles; and on the other, or southern side, the valley of the Chaudiere, and the St. Francis, the plain of the Richelieu, and the valley of Lake Champlain and Lake George. From the head of Lake George to the mouth of the Richelieu, is one hundred and ninety miles.

*The third* basin embraces Lake Ontario, with its southern tributary, the Genesee River, descending from the table lands of Pennsylvania, through Western New York, and its northern tributary, the Trent and Otonabee, meandering through a labyrinth of lakes which dot the uneven table land between the shore and the foot of the Northern mountains; the principal, taken in a west-east order, being Scugog, Balsam, Camerons, Sturgeon, Pigeon, Buckhorn, Mud, Salmon, Trout, Rice, Stoney, White, Belmont, and Marmora Lakes.

*The fourth* basin is that of three upper great lakes, embracing Lakes Erie and St. Clair, Lake Huron and its Georgian Bay, with Lakes Simcoe, Nepessing, and Tamagamingue, Lake Michigan and its Green Bay, together with a narrow fringe of short affluents, draining small areas in Northwestern Ohio, Northern Indiana, and Eastern Wisconsin, as well as the two principal peninsulas of Michigan and Upper Canada.

*The fifth* is the basin of Lake Superior, separated from the other great lakes by the Sault Ste. Marie, and fed by the smaller lakes and rivers from the unexplored lands beyond.

*The sixth* is the great general basin of the North; a country of unknown extent, studded with lakes, and traversed by the mighty branches of the Ottawa, by the St. Maurice, and by the rivers flowing from all sides into the Lake St. John, and Saguenay.

The first, or tidal basin, of the Gulf and Lower St. Lawrence, is in fact a prolongation

of the basin of the St. Lawrence proper, eastward, beyond Three Rivers, and differs from it no otherwise than in being tidal, and therefore, also, of greater breadth. As it is of no particular interest in the discussion of the hydrography of the flowing waters of Canada, and as its limits are also prolongations of the limiting mountain ranges of the basin of the St. Lawrence River proper, no further notice of it seems necessary, than to mention that the influence of the tide is felt upon the surface of Lake St. Peter, a broad expanse of the river, beyond the stated head of tide at Three Rivers. The St. Maurice River enters the St. Lawrence not far below this lake, its embouchure being nearly on the boundary between the two first basins. This point is ninety miles above Quebec, where the lower river, as it is called, commences. The Saguenay comes into it one hundred and ten miles below Quebec; and one hundred and twenty miles still further down, at Point des Monts, the estuary, widening suddenly on the north, may be considered as merging in the Gulf, but the south shore moves forward in an unbroken curve for one hundred and thirty miles more to Cape Gaspé. The whole length of the tidal basin may be therefore called four hundred and fifty miles. The basin of the St. Lawrence proper is limited, both on the northwest and on the southeast, by mountain ranges. That on the north is called the range of the Laurentide Mountains. That on the south is called by various local names, but may be termed the range of the Green Mountains. The Laurentide Mountains begin in Labrador, at the Straits of Bellisle, and run on in a southwest direction parallel in several instances, spreading out southwards so as to form bold bluffs and mountains close to the water's edge, as at Cape Tourment, which is sixteen hundred feet high; they range at an average distance back from the Gulf and river from twelve to fifty miles; across the Saguenay and behind Quebec, across the St. Maurice and behind Montreal, up the Ottawa to the Lac des Chats, a distance of at least seven hundred miles. They form the northern background to all the pictures of the river scenery. They are composed of the oldest rocks known to geological science, and spread themselves at an average elevation of about two thousand feet above the sea, back from the front line just described, over a table land of forests and lakes, far towards the waters flowing into Hudson's Bay; westward, beyond Lakes Huron and Superior; and southward, across the Ottawa to the foot of Lake Ontario, and across the St. Lawrence at its outlet from the lake, into Northern New York, filling up the country west of Lake Champlain with mountains, some of which exceed five thousand feet in height above the sea. The western or head line limit of the St. Lawrence River basin is at the foot of the Laurentian rocks, from Lac des Chats on the Ottawa, to the Thousand Islands on the St. Lawrence. Its northern border is formed by the Laurentide Mountains north of the Ottawa, and its southern by the Laurentian Adirondack Mountains of New York, along the Canada Boundary Line. The triangular space between the Ottawa and the St. Lawrence, with its apex at Montreal, is a great

plain of almost horizontal lower Silurian rocks, covered with variable depths of post-tertiary clays, showing themselves in remarkable terraces around the border lines, at an average elevation of two hundred feet above the plain. Five or six masses of trap form as many isolated mountains, from six hundred to twelve hundred feet high, standing upon the plain like stranded ships upon a beach. One of these is the mountain of Mont Royale. Around these island-mountains the terraces of post-tertiary clay are visible. The plain, however, is not confined to the triangular space between the two great rivers; it spreads on eastward, past the Richelieu and Lake Champlain, to the foot of the Green Mountains, next to be described, and so along the range past the Yamaska and St. Francis, in a long and narrow belt, even to Quebec. The whole area of this plain thus described contains about eighteen hundred square miles, the most of which is fertile arable land, well watered and level, through the midst of which flow the two great rivers named.*

The only important adjunct of the basin of the St. Lawrence proper is to be found in the extension of this lower Silurian plain southward up the Vermont, or eastern shore of Lake Champlain, the western, or New York shore of which rises at once into the Adirondack heights. Starting from the head of Lake Champlain, a narrow winding gorge between high mountains of Laurentian rocks terminates in Lake George (so famous among tourists), the upper end of which is separated only by seven miles from one of the principal head rivers of the Hudson, the difference of elevation, however, in favor of Schroen River being at least five hundred feet.

We must now describe the eastern portion of the southern barrier of the St. Lawrence basin. It has no connection whatever with the western portion already described. Lake Champlain, with its side plain of lower Silurian rocks, opening up a great highway between Canada and the Atlantic States, isolates the Adirondack Mountains on its western shore from the Green Mountain range, from which its eastern affluents descend. Unlike the Laurentide Mountains on the north, the southern limit of the basin is a corrugated plateau or chain of parallel ridges of quartzite, slate, and limestone rocks, of lower Silurian age, about fifteen hundred feet high, upon the top of which rise to a still loftier elevation the Schick-Shock, and other isolated groups of synclinal lower Silurian mountains, probably connected geologically with the Katahdin Mountains of Maine, and the White Mountains of New Hampshire. Commencing at Cape Gaspé, this barrier ranges along the southern shore of the Gulf and Estuary, in a graceful curve, three hundred miles, to the neighborhood of Quebec, where it leaves the river, by slowly diminishing the radius of its curve, towards the south. Crossing the Chaudiere and St. Francis, the waters of which

* A view of this plain, looking southeast, bounded by the mountains just described, from the mountain of Montreal, accompanied the memoir.—PUB. COM.

drain back valleys, it skirts the great plain, and enters the State of Vermont, which it traverses under the name of the Green Mountains, three thousand feet high. It is continued as the Berkshire Hills in Western Massachusetts, and as the Taconic Hills in Eastern New York; crosses the Hudson as the Highlands of West Point, and the Delaware as the Durham, or Easton Hills. Lost for a few miles between the Schuylkill and the Susquehanna at Harrisburg, it re-emerges from beneath the New Red plain as the chain of the South Mountains of Southern Pennsylvania. In Maryland, it crosses the Potomac at Harper's Ferry, to form the Blue Ridge of Virginia, and the Smoky Mountains which divide Tennessee from North Carolina; where the Black Mountain group, a little east of the line, attains elevations ranging between six and seven thousand feet above the sea. Traversing Georgia, the chain sinks beneath the Cretaceous plain of Middle Alabama, and is seen no more, after having a geographical range of not less than sixteen hundred miles.

The geological cause for the shape and position of the estuary and lower river of the St. Lawrence must not be overlooked. It is to be found in the presence of a remarkable fault or fissure in the crust of the earth, running close along the southern shore from Gaspé to Quebec, thence through the middle of the plain up the east shore of Lake Champlain, and down the Hudson River into New Jersey. All the rock formations on the northern and western side of this fault, both in Canada and in New York, are thrown down to a depth varying from five to ten thousand feet. The top of the lower Silurian system in the west wall of the fault, is brought down to a level with the bottom of the same system in the east wall. In these soft Hudson River slates, as they are called, have therefore been excavated, all along on the west side of the fault, the estuary of the St. Lawrence, the Lakes St. Peter and Champlain, and the Hudson River valley; for the same agency brings abruptly to an end in the Catskill Mountain, three thousand feet high, on the west bank of the Hudson River, the Alleghany Mountain system coming up from the southwest through Middle and Northern Pennsylvania.

Passing now to a description of the basin of Lake Ontario, its limits are of quite another order. Its eastern end abuts against the Laurentian rocks of the Adirondack Mountains of New York, and its outlet is over the low and narrow barrier of the same forming the Thousand Islands. The lake itself is excavated out of the soft lower Silurian rocks described. The northern limit of the basin is an east and west line, about fifty miles back from the northern shore; the western continuation of the Laurentide Mountains in their course from the Thousand Islands to the foot of Lake Simcoe. Its southern limit is made by three remarkable escarpments, ranging in parallel east and west lines from the Hudson River to Lake Erie, caused by the broad outspread and almost imperceptible southern dip of the whole Palæozoic system, from the Potsdam sandstone at the bottom of the Silurian, to the coal beds at the bottom of the Carboniferous rocks. This dip being towards the

south, and away from the great lakes, the basset edges of the formations necessarily front the north, and form a series of steps or terraces facing the north, while down the southern slope of these strata flow all northern subsidiaries of the Delaware, Susquehanna, and Ohio Rivers, almost from the margins of the lakes themselves.

The lowest escarpment is that of the Niagara, or Middle Silurian Formation, which commences at a slight elevation between Albany and Utica, along the south side of the Mohawk Valley, and crosses the Niagara River at Lewiston. Back of this runs the escarpment of the Helderberg, or Lower Devonian limestones, forming high hills south of the Mohawk, but dying away as it approaches Lake Erie. Still further south, and at a still higher elevation, runs the high escarpment of the upper Devonian sandstone, from the base of Catskill Mountain, on the Hudson, to Lake Erie, along the southern shore of which it ranges away beyond Cleveland into Southwestern Ohio. On the summit of this uppermost platform, and at an elevation of fifteen hundred feet above the sea, and one thousand feet above Lake Erie, lie outspread the broad, flat, shallow basins of the bituminous coal field of Pennsylvania and Ohio, constituting the great Appalachian coal basin. From the northern part of this coal field the Genesee River cuts down through all the escarpments into Lake Ontario.

Across the soft Lower Devonian terrace, between the middle and upper escarpments, lie in parallel north and south cut valleys, the deep and narrow Lakes Canandaigua, Cayuga, Seneca, Crooked Lake, Auburn, and Skaneateles, all of them, with Lake Oneida at the foot of the lowest escarpment, drained by the Oswego River into Lake Ontario. But the principal drainage of Southern New York, even from the edge of the Niagara escarpment, is the other way southward, through the upper escarpment, and by deep gorges in the Alleghany Mountains of Pennsylvania, by the Susquehanna River, and Chesapeake Bay, into the Atlantic. In Western New York, the same set of the waters away from Lake Erie carries the drainage into the Alleghany, the Beaver, and other affluents of the Ohio, the head waters of which, therefore, overlook Lake Erie, a thousand feet, from a distance of scarce a dozen miles. There is one spot in Potter County, Pennsylvania, where the same cloud will shed its waters by the Genesee into the Gulf of St. Lawrence, by the Susquehanna into the Chesapeake Bay, and by the Alleghany into the Gulf of Mexico. Following the lowest or middle Silurian escarpment across the Niagara River, we see it become the constant limit of the basin of Lake Ontario.

At Lewiston Heights it is three hundred and sixty feet above the lake. Rising slowly as it enters Upper Canada, it sweeps close around the head of the lake, runs northward, and then northwest along the southwest shore of Georgian Bay, and projects into Lake Huron at Cape Hurd; casting off southwestward all the way the waters of the peninsula into Lakes Erie, St. Clair, and Huron, and forming a well-defined barrier for a separate

water-basin between three hundred and four hundred feet above that of Lake Ontario. On the top or back of the escarpment, south of Georgian Bay, are piled upper Silurian strata to an elevation of fifteen hundred feet above the sea, in what are called the Blue Mountains. By the run of the escarpment, Georgian Bay would seem to be excluded from the region of the upper lakes, and to belong properly to the area of Lake Ontario. It and Lake Simcoe, in fact, lie in an excavation of the same lower Silurian rocks with the Gulf of St. Lawrence, Lake Champlain, and Lake Ontario, and in the prolongation of the belt of small lakes to the north of Lake Ontario. A water communication by these larger lakes and the streams which connect them, has been, in fact, accomplished by means of a system of canals, which has replaced the old portages or carrying places where no navigable water passages existed. Yet in spite of this geological and commercial connection, Georgian Bay is an arm of Lake Huron, and at a level above Lake Ontario of three hundred and forty-four feet, while Lake Simcoe, which communicates with it, lies one hundred and thirty-three feet higher. The explanation of this anomaly is to be found in the rise of the surface of the lower Silurian rocks in that direction, the whole broad outcrop being covered over with a sloping plain of northern drift, among the hillocks and ridges of which lie the smaller lakes, and a barrier of which effectually cuts off all hydrographic connection between Lake Ontario and Georgian Bay. Excavated, as has been said, in the same soft rocks of the lower Silurian system, in which Lake Champlain and the Gulf of St. Lawrence have been excavated, Lake Ontario would form part of the same water-basin with them, were it not for the intervention of the Laurentian rock barrier at the Thousand Islands. There was a time, no one doubts, and that in recent geological days (when this part of the continent was submerged from three hundred to four hundred feet beneath the present ocean level), that two broad estuary connections were established between it and the ocean: the one round the Adirondack Mountains to the north, over the plains of Montreal, the other to the south, through the valley of the Mohawk. At that time, of course, Northern New York was one island, and Vermont and Western Massachusetts was another; while the north shore of the Gulf of St. Lawrence extended up along the foot of the Laurentide Mountains to the Lac des Chats.

*The basin of the Devonian lakes*, as they are called, is now to be described. The Niagara barrier seems to end at Cape Hurd, the north of Georgian Bay, but is, in fact, continued as the Manitoulin Islands around the head of Lake Huron, and the foot of Lake Michigan, through the Straits of Mackinaw, and forms those two remarkable promontory peninsulas which almost isolate Green Bay from Lake Michigan, in the same way as the escarpment isolates the Georgian Bay from Lake Huron. Geologically considered, Green Bay is yet another of the lower Silurian lakes; while hydrographically, it is but an arm of Lake Michigan. The Niagara barrier, much attenuated, and therefore low, continues south-

ward to the head of Lake Michigan, obliging the waters of Wisconsin to feed Green Bay before they can enter Lake Michigan.

Curving round the head of Lake Michigan, the Niagara rocks sweep eastward in a narrow belt to the head of Lake Erie, thus closing a hydrographic, as well as a geological circle, around the great peninsula of Michigan, with its isolated coal basin in its centre. In troughs hollowed out of the concentric belt of soft Devonian shales, just inside this circle of Niagara rocks, lie Lakes Michigan and Huron; and in a third trough excavated from the same shales, thrown eastward by the great Detroit and Cincinnati anticlinal, lies Lake Erie, also. This anticlinal is a swell of the earth's crust, separating the Appalachian coal area of Eastern Kentucky and Tennessee from the coal area of Western Kentucky and Illinois, and casting off the rock-dips gently east and west from its broad back. Commencing in Tennessee, it crosses the Ohio in the region of Cincinnati, and the head of Lake Erie into Upper Canada. But for this anticlinal Lake Erie would have had no existence; and the other two lakes must then have emptied their waters by way of Georgian Bay into Lake Ontario.

The escarpment, limiting Lake Erie on the south, has already been described, and the disposition of the head waters of the Ohio to form along its summit and flow south. In like manner, but in a more remarkable degree, the belt of Niagara rocks, circling around the head of Lake Michigan, cuts off the drainage into it. The head waters of the Illinois, a tributary of the Mississippi, and of the Wabash, a tributary of the Ohio, start close to its margin on their long career to the Gulf of Mexico. In fact, there is a marsh but five miles back of Chicago, only seventeen feet above the level of the lake, and in wet seasons its waters flow partly into the lake and partly down the Illinois, as will be described more particularly in another place. Only at the head of Lake Erie can drainage be said to enter, in any abundance, the Canadian Basin. Here the Miami brings in the waters of a belt of Lower Devonian country of no great size, lying along the anticlinal in Northern Indiana.

*The basin of Lake Superior* lies apart from the other great lakes, at the extreme northwest limits of the formations which have been described. Its immense area, and profound trough, nearly eight hundred feet deep, excite new interest by their surroundings. Hollowed out in part from the lowest Silurian rocks, it is the highest of the lakes. Its mineral resources, copper and iron, belong to still older formations, which surround it on all sides except the south. Laurentian and Huronian mountains support a back country of forests and lakes of great extent, which pour their waters into all its shores, and offer commerce with the unknown regions of the interior of the continent: in fact, the western end of the great northern basin drained by the Ottawa, St. Maurice, and Saguenay.

All that can be said of this northern basin is, that it is a wilderness of small lakes, the

areas of which, if summed together, would make a water surface nearly, if not quite, as extensive as Lake Ontario, and of rivers rivalling in magnitude the largest affluents of the St. Lawrence.

The Ottawa, by which the waters of this region find their way out of the Laurentian mountains, at the Lac des Chats, upon the plain of Montreal, is so copious of flood, that it colors with its brown waters the north side of the current of the St. Lawrence River as far down as Lake St. Peter; just as the turbid waters of the Missouri color the west side of the Mississippi far below St. Louis. Large as the St. Maurice River is, it is not larger than the Gatineau, one of the northern branches of the Ottawa. The Saguenay is but a tidal estuary arm of the Gulf of St. Lawrence, the outlet of Lake St. John; but into this also flows from all sides the drainage of another section of the same area. Reviewing, then, the narrow southern and western border, and feeble tributaries of the chain of great lakes, and the small rain areas of the peninsulas of Michigan and Upper Canada inclosed between them; and on the other hand, the great outspread of the northern basin, its many large rivers and standing lakes, it may be justly said that the basin of the St. Lawrence is the basin of Canada; that it belongs almost wholly to the North, and finds its grandest hydrographic traits of character in a country almost unexplored. Its whole area Sir William Logan has stated at five hundred and thirty thousand square miles, more than eight-tenths of which he says belongs to Canada, and the residue to the United States. Its chief peculiarity lies in the reservoirs of water, great and small, scattered over almost its entire surface, protecting its rivers from those disastrous floods which desolate the river banks of other regions of the world, especially the neighboring valleys of the Western States. So effectual is this protection, that the total variation of the level of the St. Lawrence River, due to excessive rains or melting snows, and exclusive of the local influence of the ice-gorges at its narrows, does not exceed three to four feet; whereas the Ohio River at Cincinnati has been known to rise sixty feet in as many hours.

Having now described the leading features of the topography of the basin, and shown how this must depend so largely upon the geological features of the whole district, it will be interesting to refer to a table which has been prepared in considerable detail, and submitted, in the Appendix, marked 5, giving a list of the various lakes. It will be seen that sheets of water, besides the larger lakes, the names of which have frequently occurred in this description, are very numerous, and that they are found extending over a vast area of country principally on the north side of the longitudinal axis of the basin.

It may be said that all the largest of these lakes are hollowed out in the old Laurentian formation, and in its bands of limestone; and, as has been mentioned, similar depressions occur in the azoic rock of the Adirondack country. The smaller lakes occur, also, to a very large extent, in drift on both sides of the axis of the valley; and of these we may

mention the series lying upon the course of the Otonabee and the Trent, on the north side of Lake Ontario. But the most extensive development of these small surfaces of water occurs in that flat region of country forming the great southern peninsula of Michigan, which is generally described as covered with a great thickness of drift.

In the course of the Michigan survey, the topographers have already laid down on the maps fourteen hundred and twenty-five lakes, occupying areas of from one thousand to three thousand five hundred acres, which would be in the proportion of one acre of water to thirty-nine acres of land.

We cannot properly pass from this subject without referring to Lake St. Clair, which is only a shallow depression in the drift. It consists of an expansion of the straits leading down from Lake Huron to Erie, and may be assumed as twenty-one miles in length, by eighteen and a half in width. Its depth, as will be seen by the section, is only twenty feet, and like Lake Erie, which does not exceed eighty-four feet, is the recipient of the alluvial deposits of the rivers which flow into it. The inlet to Lake St. Clair is an interesting delta, and islands of alluvium are constantly forming, which tend to choke up its numerous channels. Although the average depth of Lake St. Clair is about twenty feet, the navigation through it has to pass a channel which is naturally about ten feet; and the dredging out of this channel to the depth of thirteen feet, by the United States Government, is referred to in another part of this paper.

A moderate gale of wind soon raises a sea in this shallow lake, causes the whole to become turbid, and tends thus to distribute the detrital matter, and to convey it through the Detroit straits into Lake Erie, where similar accumulations, on a larger scale, occur. The depth of Erie over its upper end scarcely averages eighty feet, its deepest part being near the east end, where it begins to narrow towards the outlet, in the direction of Niagara. Here, too, an ordinary storm raises a very heavy and somewhat dangerous sea, and soon disturbs the bottom, and favors the distribution of natural deposits which settle in calmer weather in the *upper* portion of this shallow basin.

Reflecting upon the relative levels of these upper lakes, as given in the table before referred to, and the peculiar character of the water-shed which limits the basin on the west side of Lake Michigan, it will be seen that if the barrier now regulating the discharge through the Niagara River were lifted to the extent of about thirty feet, the whole of the great lakes would be converted into one vast sea, on a uniform level, which, while placing under water from eight to nine thousand square miles in Western Canada and Michigan, and the other borders of the lakes, would determine the direction of the outlet of this great basin towards the Mississippi, and place the present dividing ridge from seven to eight feet below the surface of this expanded sheet of water.

## RIVER ST. LAWRENCE.

The whole of the River St. Lawrence, from its entrance at Pointe des Monts to Montreal, has been elaborately surveyed by Admiral Bayfield; and the charts and sailing directions which are published by the Admiralty are so extensive and so well known, that it is deemed wholly unnecessary to make any statements with respect to the navigation of the tidal part of the river.

The tides at Quebec range, upon the gauge which is there fixed, from eighteen feet at spring tides, to thirteen feet at neaps. Unusually high spring tides, accompanied with gales of wind from the northeast, occasionally give from two to two and a half feet more at high water, and a smaller range towards low water, but the mean for all practical purposes, may be taken at seventeen feet. At neaps the tides range about eleven and a half feet, the low-water level both at spring and neaps rarely varying more than eighteen inches. Spring tides are felt up the river as far as the entrance into Lake St. Peter, which for all hydrographical purposes may be described as the head of tidal navigation. From this point onwards the river has for some years past been the object of constant superintendence; and works of considerable magnitude have been carried out for improving this navigation, together with that of the river up to the harbor of Montreal.

The depth of water existing on the Flats of St. Peter in 1845, is reported by the authorities as only capable of passing vessels drawing not more than eleven feet at low stages of the river, and other impediments existed in the river above. But under the direction of the Harbor Commissioners of Montreal, a general deepening of the whole of the fairway of the navigation, wherever necessary, is being carried out. The works consist of a channel dredged out in the clay and mud bottom of Lake St. Peter, three hundred feet wide, and is intended to afford a depth of water, when completed, of twenty-one feet at low water.

According to the statements made to the Harbor Commissioners by the Engineer, to the end of 1860, the work has been proceeding with great vigor. There are five dredges employed, with hopper barges and scows; and the work performed during the year 1860, stated to have been two hundred and seven thousand seven hundred and thirty-two cubic yards, at a cost of \$57,527, or \$0.27½ per cubic yard excavated, including superintendence, but exclusive of the interest on the cost of machinery and boats. From this point to Montreal, the general course of the river is direct, although the fairway of the channel is somewhat tortuous, and there are many islands of alluvium which divert the direction of the fairway, but all the courses are duly marked and lighted, and during last year no difficulty was felt in clearing vessels through the improved channel between Montreal and Quebec, drawing nineteen feet of water, the Flats of Lake St. Peter having then about

twelve feet of water on them. The slope on the surface of the river, from the head of Lake St. Peter to the foot of St. Mary's current (which is a small rapid at the lower end of the harbor of Montreal), is about two and three-quarter inches per mile, and the average velocity is one and a quarter miles per hour in the fairway channel. The rapid last mentioned is formed in a contracted part of the river, between St. Helen's Island and the north shore, which is here about two thousand feet across. The current through the rapid, in ordinary stages of the water, is about four and three-quarter miles per hour, but occasionally reaches from five to five and a quarter miles per hour.

The harbor of Montreal is shown by the annexed plan, and has wharves for accommodation of the traffic which it has for the last few years obtained, and which exceeds two hundred and fifty thousand tons per annum. This accommodation has been obtained by building wharves of cribwork out into the stream of the St. Lawrence, and by dredging out a suitable depth for vessels to lie alongside. This harbor was, until the construction of the canals, the head of navigation for sea-going craft; and until the commencement of the canal system, the real difficulties of the navigation of the river began at this point.

It was a great thing to witness a river, rarely less than two miles in width, gradually extending to twenty miles, flowing for five hundred miles of its course with great regularity for eight months in the year, and affording accommodations for square-rigged ships of six hundred tons, which then reached Montreal; it was another thing to attempt the movement of freight from this point upwards. The work up the Valley for the first ten miles above Montreal, was performed either by the Portage Road, so called, or by dragging up by the sides of the rapid current, with long teams of oxen or horses, sometimes in, sometimes out, of the water; and such portages as these occurred at nine distinct points between Montreal and Kingston, and similar portages were also necessary on the Ottawa.

The work was chiefly done by canoes or large bateaux, which rarely exceeded twenty-five tons burden; and it may readily be understood how the freights and charge, for the movement of goods and passengers, acted as a most formidable barrier to progress in the settlement of the country; and as movements over the deep alluvial soil of the valley, in a state of nature, could only be undertaken either in the driest season of the year, or in sleighs over the snow, it is not surprising that forty years ago, the settlements of Canada consisted only of a few villages and farms fringing the most favorable sites on the banks of the river and Lake Ontario. Still more difficult of access was the country, and more sparse the population of those then remote regions on the border of the upper lakes.

The Niagara Portage was, however, established early in the present century, and assumed a great importance up to the time of the completion of the Welland Canal. While up the Ottawa, the country at the beginning of the present century, on both sides of the river,

could have advanced but little in material prosperity and settlement since the time when the Jesuits narrated (in their most interesting letters written one hundred and fifty years before), their occasional visits to these regions.

There are, however, two periods which we must now mark, as the first great steps towards the real progress of the country; and one of these which has only fulfilled in American waters what has been the result in all others, is that of the commencement of steam navigation; the other is the establishment of the canal system.

It is an agreeable fact to state that on the River St. Lawrence, and on Lake Champlain, almost the first successful attempt was made to employ steam for the propulsion of vessels; and the following narrative, drawn up by a local committee, will be read with some interest by engineers:

"In 1807, Fulton first launched his first steamer on the Hudson. In 1809, his example was followed on Lake Champlain and the St. Lawrence.

"The first movement towards the steam navigation of the St. Lawrence was made by the late Hon. John Molson, in conjunction with David Bruce, a shipbuilder, and John Jackson, an engineer.

"The vessel built by them was the 'Accommodation;' she was but a small boat, seventy-two feet in length, with sixteen feet beam, propelled by an engine constructed by Mr. Jackson, of not much exceeding six horse power.

"It required no ordinary courage and enterprise on the part of these pioneers, to undertake the difficult task which they thus essayed. But all the difficulties encountered were successfully overcome, and on All Saint's Eve, 1809, the steamer started on her first voyage to Quebec. As she passed after nightfall some of the settlements, going without sails against an easterly wind, the sparks flying out in a continuous stream from her funnels, as has been the case elsewhere, the consternation of the inhabitants residing along the banks of the river, at the unwonted sight, must have been very great; and we can easily suppose that it might well be taken for some phantom ship, or other fearful apparition. It was held dangerous to continue their progress through the night, and three days were consumed in the downward trip of one hundred and eighty miles to, and four days in the upward one from, Quebec. Therefore it was, that those who had to reach Quebec either by the tedious land route or the more uncertain transport of sailing craft upon the river, hailed the prospect of this more swift and certain steam navigation with satisfaction. The experiment proved a failure. The engine was, of course, too weak, and of imperfect construction.

"Yet notwithstanding the lack of immediate success, and the money lost by the first attempt, Mr. Molson did not abandon the enterprise. His practical mind saw, even in that failure, the certainty of a final success, which he lived to realize. He went to England,

and there contracted with the firm of Bolton & Watt, for the engine of a larger boat, some of the castings and rougher part of which were made in Lower Canada. The London engine builders could build the engine, but they knew nothing of the appliances by which it was adapted to navigation: these required to be furnished here.

"In 1811, the new vessel, the 'Swiftsure,' was launched and at work, and in 1812, did 'the state some service' in the transport of troops and stores during the unhappy interruption of our relations with the United States. This boat had nearly five times the power of the 'Accommodation.' Her length was one hundred and twenty feet, her beam twenty-four feet, the engine was rated at twenty-eight horse power, and she was fitted up and equipped in all respects in a superior manner.

"The 'Malsham' was the next boat placed on the line, still superior to the 'Swiftsure;' and after her the 'Lady Sherbrooke,' vessels at that time of very considerable tonnage and power.

"At this period the river was not lighted and buoyed as at present: it was, therefore, thought unsafe to run after dark. The pilots, too, were less experienced than at present: it was, therefore, usual to anchor at night. Frequent and expensive delays were also caused by strong southerly winds in getting up the current St. Mary, more especially when the boats were heavily loaded, as they generally were at that time. Oxen and horses were sometimes employed to tow the vessels up this very powerful current.

"In a few years later than the period referred to, we find the St. Lawrence Steamboat Company, and their competitors (afterwards their coadjutors) the Montreal Towboat Company, running their boats during the night with perfect safety, and ascending the current in any state of the wind, triumphing over all the former difficulties of the navigation.

"To the late founder of the St. Lawrence Company, the Hon. John Molson, the celebrity of being the first to establish steam traffic on our noble river must be accorded,—a traffic which, by the enterprise of Upper Canada and that of our neighbors in the adjoining States, is now made to enter from Superior City, on Lake Superior, and Chicago, on Lake Michigan, to the ocean,—aye, and across the ocean, also.

"To the late Robert Hamilton, Esq., Upper Canada is indebted for the first steamer on Lake Ontario, the engine of whose boat was constructed from the model of the 'Malsham's' engine.

"In contrast with the dimensions, power, and speed, of the little 'Accommodation,' we subjoin those of the 'John Munn,' the largest steamer now (1856) plying between this city and Quebec:

| | |
|---|---|
| Length, . . . . . . . . . . . . . | 312 feet. |
| Breadth of beam, . . . . . . . . . . . | 29 " |
| Cylinder, . . . . . . . . . . . . . | 72 inches. |
| Stroke, . . . . . . . . . . . . . | 11 feet. |

"She makes the downward trip easily enough in ten hours, and the upward in from eleven to twelve hours."

In 1819, the canal system was begun in the construction of the Lachine Canal, and following this, other works of the same nature, for the improvement of the Ottawa and the St. Lawrence, which will hereafter be described.

From Montreal, up the natural course of the river, there is a series of rapids which give a high velocity to the water, in some cases not less than eighteen miles per hour, which give rise to a rapid turbulent stream, over a rocky bottom of an uncertain depth; alternated with lakes or wider stretches of the river, which have reduced the velocity to a minimum of half a mile per hour, in the centre of Lakes St. Louis and St. Francis.

The portion of these rapids and lakes, as well as the width and depth of the river, can be best described by referring to a map, which is appended to this statement, giving all the leading features for the practical consideration of this subject. And attention is particularly invited to the large general charts of the river from Brockville to the neighborhood of Montreal, which afford the best available material for the study of this interesting river. A tabulated statement is also given in the Appendix (marked 7) to this, which gives the slopes of the surfaces; but it may be remarked generally, that while the maximum slope in the Sault Rapid is on an average seventeen feet per mile, the minimum slope of the flat part of the river, between Brockville and Prescott, where flowing in a tolerably uniform *regime*, is one inch per mile for a length of about twelve miles.

It is to be regretted that circumstances have not encouraged or induced the undertaking of any sufficiently extensive observations upon the discharge of this river, through these or any other localities; for unless undertaken professionally, it is scarcely to be expected that a zealous devotion to science *per se*, would venture upon a set of experiments which, to insure sufficient accuracy, must be continued over a long period, and especially under circumstances such as those which have been referred to in another part of this paper.

## ST. CLAIR FLATS.

Among the works undertaken on the line of inland navigation, is the deepening of the St. Clair Flats, forming the delta at the head of the shallow lake elsewhere described. Up to the year 1856, great inconvenience was felt at this point, particularly at low stages of the western waters, where there was barely six feet of water in some places; and to escape the shoals and shifting sands (which in rough weather were even dangerous), it was the common practice to lighten, at a considerable cost, a part of the cargoes of the ordinary lake schooners.

The attention of the United States and Canadian legislatures was at length success-

fully drawn to the subject, and appropriation was made accordingly, to effect the clearing up, and buoying and lighting of a channel; and since that time, viz., from and including the year 1857, to the end of 1858, the total quantity of dredging done was one hundred and fifty thousand seven hundred and sixty cubic yards, and the channel at the upper end was made two hundred feet wide, the average width being two hundred and seventy-five feet wide.

The channel is now excavated to insure a minimum depth of twelve feet throughout; and in the middle of the channel, for a width of two hundred and thirty feet, the depth is thirteen feet.

The total appropriation to the work was $45,000 from the United States Government, and $20,000 from the Canadian Government, and the work has hitherto appeared to be perfectly satisfactory; and the South Pass is now the master current into the lake.

The material excavated was removed to a distance of five hundred yards from the channel, and re-deposited in the lake. It consisted for the most part of sand, gravel, and mud, with a little hard-pan and drift, corresponding with the drift found on the Michigan peninsula.

The cost per cubic yard was:

| | |
|---|---|
| Sand, gravel, and mud, . . . . . . . . . | $0 30 |
| Hard-pan, or concreted clay and sand, . . . . . . . | 1 50 |

There are three main channels or passes through the delta, known as the North, Middle, and South Passes,—the latter being the one selected for the operations described, and forming the boundary line between Canada and the United States.

## ICE.

The phenomena attending the formation of the ice, and its removal, which form the natural limits to all the economical operations of the people living within the district, deserve especial consideration. During the long winters, in the earlier periods of the history of the country, the people were driven to their homes, without much occupation beyond what was essential to the support of existence. It was a period of four months, with a mean temperature of twelve degrees below the freezing point,—but with extreme fluctuations, of deep snows,—and during which, if they could not obey the same instincts which led most of the animals of this vast region to migrate, they would follow that of others which were fitted for hibernation. It is this curtailment, perhaps, of a third part of the year which has encouraged—if it has not developed—that remarkable activity and change in habits (rapid as the changes of the temperature itself), observable in every person and in every operation, upon the opening of navigation.

*Travelling* through the Northern country, and the *transportation of goods*, during the open seasons, since the discovery of Canada, were chiefly carried on through the lakes, rivers, and streams, in bateaux, or canoes hollowed out of pine logs,—or in the still more fragile craft, birch-bark canoes,—which were hauled out at rapids and falls, and carried around by the Portage roads to the navigable water above or below, as the case varied.

These brought into action a peculiar class of hardy French-Canadians, with Indians and half-breeds, all known as "voyageurs;" and it is not to be wondered at that the opening of the long-frozen waters is hailed with pleasure, as the commencement of a new existence, in the interior of the country.

The temperature of the lakes and rivers, and of the soil, has been referred to; and the study of a sufficient number of observations would probably enable us to define the general laws of cooling: but all the leading phenomena connected with the advent of winter, and with the well-established but slight moderation, known as the "January thaw," the mode and time of breaking up of the ice, have naturally been long and patiently watched and noted; and as the variations of temperature and their effects on the streams and rivers are again and again repeated, with much general regularity, there is little room for error in taking only a few years' observations for the establishment of the leading general characteristics of a given locality: and the uniformity of recurrence in the phenomena under consideration is one of the most striking features of the natural history of the country.

The average number of days of closed navigation is:

| | |
|---|---|
| At Quebec, | |
| At Montreal, | 145 |
| Of the St. Lawrence Canals, | 135 |
| Of the Ottawa, | |
| Of the Lake at Kingston, | 90 |
| Of Lake Erie, at Buffalo, | 130 |
| Of the New York Canals, | 134 |
| Of the Welland Canal, | 116 |
| Of the Detroit River, | 117 |
| Of the Sault Ste. Marie Canal, | 156 |
| Of the Illinois and Michigan Canal, | 118 |

The few frosts which occasionally occur early in October, and effect that remarkable change in the color of vegetation so often dwelt on by those who have resided in, or visited, during the "fall," the northeastern portion of the continent, are generally followed by unsettled weather, with occasional heavy rains, and a temperature corresponding to the mean of the year. This is succeeded, early in November, by a slight flurry of snow, and then by a warm and genial season, with an increased degree of moisture in the air, and a

peculiar haze, much resembling our season of early October, in the southern counties of England, and is called, in the transatlantic country, the "Indian Summer." This charming period is suddenly terminated by cold, clear weather, and by about the 25th of November, the still waters become frozen on the surface. Generally by the 5th of the following month, there is a fall of more or less snow, which, while covering with a protective mantle, and retarding the cooling of the earth, aids the formation of the "ground ice," or "anchor ice," in the streams.

The author, having attentively watched the formation of this description of ice, recognizes it as the precise repetition of the same phenomenon in the Thames and Kennet, of England.

The results of his observations in England, on the rivers named, have been supported by similar observations in American rivers, and serve to show that the primitive crystals of ice formed first in contact with the cold air, at the surface of the streams, or derived from snow falling thereon, are carried down, by counter-currents and eddies, below the surface, where they become fastened to the best conducting media. Occasionally portions of the agglutinated mass are broken off by the force of the current, or by other causes,—among which may be, and probably is, the change in the atmospheric pressure, and in the temperature of the stream, and consequent change in specific gravity, which would induce the rising of the mass to the surface; and in the large American rivers this soon takes effect, and the whole becomes frozen into a solid mass of field or surface-ice. Much of the ice, however, is for the time held to the bottom, by contact with stones or a rocky bed, and is then known as anchor-ice. Much travels, rolling slowly along on the bed, loaded with gravel or sand, which increasing the specific gravity of the mass, prevents its rising to the surface.

Soon the small bays and indentations of the banks fill up, and shallows become more effectual barriers to the stream, producing comparatively still waters, which, under the influence of the *all-pervading* cold, with the increased falls of snow, augment the thickness and strength of the floating masses. Then begins an actual blockade, causing an increase in the height of the river, which relieves, for the moment, some of the ice and the pent up water, which flows towards the next retarding point.

In the large rivers this is particularly interesting, and some of its features are really imposing. At Montreal, for instance, the movements are possessed of a certain degree of grandeur. Here the current, before described, flowing between the Northwest Bank and St. Helen's Island, although the narrowest channel, soon becomes the master current; for that which flows through the wider and shallow space, on the south side of the island, although really in the most direct course to the lower reaches of the river, soon becomes almost blocked up. The great discharge of the field-ice, broken up first in the Rapids of

Lachine, is, to a partial extent, reset into floes in the Bay of Laprairie, above the Victoria Bridge, and approaches the St. Mary's current in such masses and quantity as soon to fill up the reaches below, which, by this time, are more or less blocked up by the accumulation of the solid field ice, which commences in Lake St. Peter, and extends for many miles upwards through the low islands and over the shallow rivers between Sorel and Berthier. The next blockade below the city forms at Boucherville, where local circumstances favor its collection. The subsequent filling up of the whole surface of the river, for about seven miles of its course, is rarely the work of three days.

Now the most interesting feature begins to show itself. The ice continues to come down in undiminished quantity and mass, and gradually reduces the channel of St. Mary's Rapid, which results in a rising of the surface to obtain the required discharge through the diminished cross section. Often temporary relief is obtained. The water falls suddenly, and rises again, for like reasons, till at length a uniform "regime" is established. During these sudden rises and falls, the ice coming down with the velocity due to the river, pushes, or shoves, and packs,—rising up and piling itself in mounds on the banks; covering the wharves—already submerged—to the extent of from two to twelve feet; mounts, generally, a retaining wall twenty feet above the ordinary level of the river, occasionally packing and piling upon it, and obstructing the wide front street, with a mound rising in some instances to the eaves of the warehouses, from twenty-five to thirty-five feet high.

In other places, as on the low islands in the river, and in shoals in that part of it opposite the city, the accumulation goes on, while the projecting upstream side of St. Helen's Island receives its share.

Doubtless the discharge of the river is, to some extent, reduced in quantity through the freezing up of streams whose volume is not regulated by lakes on their respective water-courses; and the discharge of the large lakes is also greatly reduced by the obstruction caused by the barrier of ice across their mouths; and where, as the head cannot rise in the like proportion (*i. e.* to a degree sufficient to compensate for the reduction of the hydraulic mean depth of the river at its outlet), the mean velocity and discharge must decrease. Such effect, at least, is perceived at the lower parts of the river, where, in general, from six to ten days elapse after the final taking, and all shoving has ceased. The whole surface then falls, except in those parts where the ice has grounded; for although the ice is, over a good part of the area under consideration, estimated at from ten to twelve feet thick, some portions may be deeper, and actually resting firmly on the bed of the river. There successively appear indications of shoal water; and we may recognize in some of the large mounds on the surface, when it has fallen to its final "regime" of minimum level (which is attained generally in ten days after the final taking), the

shoals and dangers of the navigation,—a sort of parallel repetition and model of the surface of the bottom.

The circumstances which have been here related occur again at most of the Rapids; and there are interesting illustrations every year at Lachine,—on no occasion or place more so than the remarkable shove which took place last December, four miles above Montreal, also at Cornwall, and in other Rapids up stream. Similar effects take effect on the river in the Richelieu Rapids, below Lake St. Peter, which generally rises far above its usual level, and causes considerable inundation in the district above this part of the river, and on both sides of it.

But perhaps the most striking feature of the season is its breaking up, which is generally attended with the same features on even a more extended scale, the average period of this being about the 10th of April; and at Montreal it has been accompanied by many curious effects, of jamming and shoving, and what is more important, by certain occasionally attendant floods, so as to render it a matter of surprise, in spite of repeated warnings, and with a past history of the river, which nature has painted in such distinct and marked lines as cannot be misinterpreted,—that the subject of a remedy has not long since met with more becoming attention from the authorities of the city, especially in the interest of a portion of it extending towards the Lachine swamp, which bears marks of its ancient office, as an important channel of the river.

The breaking up is always accompanied by the shoving, and generally with more or less packing. The photograph accompanying this paper (Appendix, marked 8), illustrates truthfully the evil to be contended with, in a special instance which was observed in 1859. In these movements are tested the value of the cribwork elsewhere described. The wharves being kept low, they are comparatively clear of the moving mass of ice; and if sufficiently loaded with stone, and left with smooth surfaces, no considerable injury results. Instances of the removal of large masses of cribwork, although known, are rare; and where they have occurred, the fact has generally arisen from want of attention to their loading, to their undue height, or to injudicious position or direction of their sides.

The tidal portion of the river occasionally "takes" at the Richelieu Rapids; and in about four years out of five it takes for a few days, at least, and sometimes even for the whole time, in the narrow gorge of the river, opposite Caronge, from six to eight miles above Quebec.

At Quebec the much wished for "taking," and the formation of a "pont," so called, is less frequent; and it seems that one year in four is about the frequency of occasions. When the ice bridge or "pont" exists, the surface is generally frozen for a considerable distance to the head of, and sometimes down both channels of the river at the sides of, the Island of Orleans, from one to six miles.

The navigation at and below Quebec soon generally becomes obstructed through the large accumulation of drift-ice in the tideway, which fills up most rapidly, and sometimes to the extent even of almost the whole surface of the river, for eighty miles down its course, before the end of January.

The manner of its accumulation is chiefly to be observed in the bays and indentations, where accumulations go on increasing until an occasionally higher tide than usual floats large fields of ice into the stream; this, of course, generally drags along the shore of the river, or becomes attached to older drift-ice, or to stones and rocks, which it grinds and rubs to a smooth, rounded, *moutonnée* surface, recognizable on all rocks subjected to glacial action, and a "bordage" accumulates, having a width and thickness chiefly affected and modified in form by winds and tides.

The experiment of landing a detachment of the British army at Bic, in the last week of December, shows that, for practical purposes, the river, although generally open at that point for about a month after the closing of the upper navigation, cannot be reckoned on with any degree of certainty so late as the time at which that landing was effected.

## WINTER AND LUMBERING.

The progress of civilization and of trade, however, in Canada, has developed occupations for the farmers in winter, who avail themselves of the frozen rivers and lakes to move heavy loads of produce which could not be carried over the unmetalled roads of this vast district of soft surface clay and marl, and, therefore, winter is now looked for with almost as much interest as the harvest.

The lumbering operations of Canada are almost all performed in the depth of winter, and while there is a great depth of snow, the trees generally being felled when there is from two to three feet of snow in the woods. These are then hewed down to suitable sizes, and hauled out by horses, on the snow or across the ice to the frozen streams, upon which they are moved forward, first singly, then in drams,—a number of which go to form a raft,—and in this state, at the opening of navigation, they travel for many hundreds of miles, down rivers, across lakes, and overcoming rapids by means of slides or shoots, having a slight depth of water to facilitate their movement. The author, however, refrains from entering upon this subject, although it is sufficiently interesting, as including some rather remarkable engineering structures and process of manufacture, affording fitting subjects for a paper which could be better supplied by those who have had long practical experience of this great element of the wealth of the British North American Provinces. Statistics, however, are added, in the Appendix marked 32, which afford very useful information touching the quantity, value, and description of the export of lumber from Quebec for some years past.

## METEOROLOGY.

The subject of meteorology has occupied the attention of the physicists of the United States, and the results of observations, collected at a variety of points over almost the whole of the continent, have led to valuable contributions to science in general. The arrangements which were suggested by, and are under the control of, Dr. Henry, of the Smithsonian Institution, at Washington, deserve especial mention; as by means of these exact predictions of coming storms have been made with actual certainty. And this is one of the collateral advantages derived from the electric telegraph ramifying, to such a prodigious extent, over the area of the United States and Canada.

The number of stations at which observations are now constantly taken daily, by order of the United States Government, under the direction of the United States Topographical Engineers, is one hundred and fifty-seven. In addition to these, it is a requirement of the regents of the public schools in the State of New York, as well as in most of the other States, and in Canada, to keep a careful record of general meteorological observations. And in addition to the yearly results which are transmitted to central points (as, for instance, in the case of the public schools of the United States to Albany), a large number of these observations are also placed in daily communication, at a particular hour, with the Smithsonian Institution, where the conductor in charge can see at a glance all that is going on. And as the results of such an extensive system enables the philosopher to test his generalizations, from hour to hour, we may expect very important developments.

All these observations seem to confirm the ideas promulgated by Dr. Henry (who supposes) that the prevalent winds are the immediate effects of the great currents of the ocean, modified by circumstances. It is supposed that the elevated temperature of the water in the Gulf of Mexico,—which is greater than that of the water in almost any other part of the globe,—is retained by the Gulf Stream until it reaches the shores of the polar basin. The southwest winds, which accompany and blow from the Gulf Stream, share its temperature; and we feel the benefits on our English coasts and climate, which is far more genial than would be due to our latitude. The southwest and westerly winds, which prevail over the surface of the United States, serve to bear the heat of the Gulf Stream from the American coast; and when an easterly wind is produced by local causes, which would bring the warm air of the Stream to these shores, it is cooled by crossing the polar current flowing south, next the shore, which reduces its temperature to the dew point, and produces the peculiar chilly effect familiar to the inhabitants of the Eastern States and Canada; while on the Pacific Coast, the west winds from the ocean cross the comparatively cool current from the north, and impart a uniform temperature to the western

slope of the Coast range of mountains, giving rise to the equal summer temperature so frequently described as prevailing on that coast.

Were the whole of North America, from the Atlantic to the Pacific, a continuous plain, and were the surface diversified merely by eminences of comparatively small elevation, the moisture from the Pacific would be carried into the interior, and a much greater degree of fertility in the western portion of the Valley of the Mississippi would exist. In the actual condition of the continent, however, the westerly wind which passes over the great mountain system which extends from north to south, along the western portion of the continent, deposits its moisture principally on the western slope of the Coast range, and gives fertility and mild climate to California, Oregon, Washington Territory, and to Vancouver's Island, and the British possessions further north. Such moisture as may remain is precipitated on the western slopes of the high ridges of the Rocky Mountains, further east; and the air becomes almost completely desiccated, leaving the elevated plains east of the Rocky Mountains an arid region, and so deficient in moisture as to be unfit for cultivation, unless by the aid of irrigation. Such is the united testimony of all those who have returned from the exploration of the open country between and away from the streams which occasionally form little oases in the great desert.

So remarkably is this the case, that it has been stated in general terms that if a prime vertical line be drawn from about the longitude of ninety-eight degrees west, striking the Gulf of Mexico, we divide the continent of North America into two nearly equal portions; that to the east being the cultivated and valuable agricultural portion of the country,—that which lies to the west, with the exception of a few isolated spots, and with the exception, also, of the western slopes of the Coast range of the Rocky Mountains, being, for the most part, an arid wilderness.

It is considered that there are two great systems of wind prevailing over the United States,—the upper from the northwest, and the lower from the southwest; the latter carrying the moisture from the Gulf of Mexico and the Caribbean Sea over the whole of the eastern States of the Union, and the eastern part of the Valley of the Mississippi, and being, therefore, the principal fertilizing wind of the interior of the continent. Were the earth at rest, this wind would flow directly northward, and would divide its vapor over the whole of the interior of the country, to the base of the Rocky Mountains; but on account of the rotation of the earth it is drawn eastward, and bears its moisture in a northeasterly direction, leaving a large space, as it were, under the lee of the Rocky Mountains, greatly deficient in this element of vegetable production.

A small map is appended to this paper, showing the general direction of the winds. The green portions of the map indicate the naturally woody regions of the country, well supplied with water from the fertilizing winds. The pink-shaded parts indicate rich,

arable prairie, along the streams through which, where there is a local supply of moisture, wood is found, but yet the whole has much less moisture than the naturally woody portions. The uncolored, or white portions of the map, within the boundary of the United States, indicate the regions so deficient in moisture, that no dependence can be placed upon them in regard to agriculture. In some parts of them, where moisture is found, crops may be produced; but as a whole they are of little value in the way of affording the necessaries of human existence, and are incapable of maintaining more than a very sparse population.

For so much of this map relating to the United States, and as an authority for the statements now made, the author is indebted to Dr. Henry.

The author has added to this statement the result of four years' observations upon the rain-bearing winds in Canada (Appendix, No. 9), by which it appears that out of the whole quantity of rain which fell at Montreal, during the years 1858, 1859, 1860, and 1861, the following proportions were derived from the west, northwest, and north, namely: 1858, 28 per cent.; 1859, 36 per cent.; 1860, 28 per cent.; 1861, 30 per cent.; giving an average for the four years of 30½ per cent., while from the other points of the compass during the same period, the average was 67½ per cent.; showing immediately the direction and tendency of the rain-bearing winds, which, while their duration is limited to only a very few days in the year, furnish about three-fourths of all the rain and snow precipitated.

The result of a series of observations on the daily maxima and minima ranges of temperature is appended hereto (Appendix, No. 9), and the diagrams for the years which have been mentioned are given in full, showing results confirming what must have struck the most general observer of the weather in the Valley of the St. Lawrence, viz., *the most remarkable and sudden fluctuations in temperature*, and in the proportion of cloud.

The two features have been projected upon the same paper, and will be studied with interest, if not on account of the particular feature mentioned, yet in regard to the more salient features of actual temperature and its extreme fluctuations. (Plates IV, V.)

Observations have been established at several points in Canada; but before arriving at any generalizations, observations would require to be continued for a much longer period. It has, however, been observed in Canada, as in those parts of New York lying contiguous, that the temperature of the months increased from the first half of February to the last half of July, from which it regularly returns to its minimum in February, as shown in a diagram before referred to. The mean of the second half of April, and of October, in the general group of observations, differs but little from the annual mean.

Lakes or large bodies of water are found to exert an equalizing influence on the tem-

perature; and at twenty-two stations at which the mean annual range is below that of the whole district, all but one are in the vicinity of lakes or rivers.

As compared with Europe, easterly winds bear the same relation to the rains that westerly winds do on our side; for in each case the humid air from the Atlantic is brought over the continent, where, upon cooling, it must precipitate its moisture. In the Northern United States and Canada, northeasterly storms are proverbial for their inclemency; whereas northwesterly winds, bringing air from which the moisture has been previously condensed, have a chilling, but not a rainy character.

A statement of the quantity of rain, as observed at a variety of stations, is given in the Appendix, No. 9; and to add to the value of those observations taken in Canada, the result of observations made in the State of New York is also given.

It will also be seen that the last rain in the State of New York appears to fall in the valley of the St. Lawrence, and the western portions of that State; and, therefore, the region of the great lakes receive a rain fall below the general average.

The rainy season is greatest in summer and autumn during the prevalence of ocean winds, and, coincidently, it is least in the spring and winter, when the land winds prevail. The least depth of rain, including snow (eight inches of which are assumed to equal one inch of rain), falls in February, the greatest in June; the quantity falling in August being nearly equal to the annual monthly mean. From May to November it is greater, and during the remainder of the year it is less than the general average.

The relative forwardness of the seasons may be best obtained by referring to a statement of the duration of closed navigation at various points, given at page 265, under the article "Ice."

With respect to the temperature of the waters of the valley of the St. Lawrence, the writer is not aware of any other continued observations than those which have been made in the River St. Lawrence, at Montreal.

The observations recorded by Mr. Hodges, in his elaborate description of the Victoria Bridge, and its works, contain some interesting matter relating to that feature of the St. Lawrence.

In order to render the subject more complete, the writer has given below the result of one year's observations on the mean temperature of the water, and the mean temperature of the air, taken at two stations, at 9 A.M., noon, and 3 and 6 P.M., for the year 1861, near to the city of Montreal. These results show that the mean temperature of the year was 45.03°; that the mean of the air, during November, December, January, February, and March, 151 days, was 24.20°; that the maximum was 47.50°, and the range 76°; and that the number of days at and below zero was 16; at and below 32°, 113; and at and below 24.20°, the mean, 75. That in the next period,—April, May, and October,—92

days, the mean was 49.23°; the maximum, 73.50°; the minimum, 21.50°; the range being 52°; and that at and below 32°, there were 8 days; at and below 49.23°, 58 days; at and above 60°, 19 days; at and above 70°, 3 days.

Of the remaining 122 days, namely, June, July, August, and September, the mean was 67.91°; the maximum, 91°; the minimum, 45.50°; the range, 45.50°. That at and below 50°, there were 4 days; above 67.91°, 86 days; at and above 80°, 14 days; at and above 90°, 3 days. The total number of days in the year below 32°, was 121; the extreme range of the year, between 9 in the morning and 6 in the evening, was $119\frac{5}{10}$°; in any 24 hours in the summer, was on July 10th and 11th, 20.50°; and in winter, January 10th and 11th, 38°. The mean temperature of the water, during the year, was 45.80°; the mean of the month of August was 69°, and of January, 30.50°. And the records show that the temperature of the water for four months, namely, January, February, March, and December, were, respectively, 30.50°, 30.55°, 31.20°, and 31.90°. The extreme range of the temperature of the water was 46°,—its maximum temperature was 75°, on the 5th of August, and the minimum 29°, on the 8th of February, on which day the minimum atmospheric temperature was also observed.

The mean temperature of the soil has been observed, for a considerable period, at Burlington, in Vermont; and also at Dr. Smallwood's Observatory, at Isle Jesus, near Montreal; and the mean temperature, at four feet beneath the surface, is stated to be 44.70°. The majority of deep springs which have been observed by the author give a temperature of 44°.

Valuable experiments have been made by Dr. Emmons, at Albany, upon the temperature of the soil, and published in the Reports of the Natural History of the State of New York. These will be studied with interest, in connection with the agriculture of the country. The developments of the curves of temperature give results in a very striking manner.

With respect to the penetration of the frost into the ground, much depends upon the nature of the soil, and character of the vegetation, or the depth of snow which covers the surface of the earth. But as a general rule, for the guidance of engineers in the country, it is stated that no water-pipes are safe at a less depth than four feet; and at this depth there were many indications of frost during the existing winter, in the trenches prepared for gas and water-pipes, in the city of Montreal.

## TEMPERATURE OF THE LAKES.

The mean temperature of the deeper parts of Lake Champlain, in winter, is said to be about 40°; and while the surface is covered with ice, it changes very slightly. In the

shallow part of the lake, near its southern end, and where the volume is but small, the temperature is very little above the freezing-point for some weeks, but in the deeper parts of it, the water rarely falls below 40°. The mean temperature of the earth in Vermont, contiguous to the lake, has been observed to be about 45°; and it is not surprising, therefore, that so soon as the cooling influences of the severe winter of this region have been mitigated, the large masses of water should first break up, and very rapidly convert the ice; and in support of this view, it may be remarked, that the latest disappearance of ice may be almost always reckoned on in the comparatively shallow exposed surfaces of the smaller lakes and ponds of the country.

Nor, under the circumstances, is it a matter of surprise that these large masses of water, these inland seas of the country, should exert a certain influence on the atmosphere surrounding them; and it has long been a matter of general observation, but is now reduced to the most tangible form by Dr. Henry, of the Smithsonian Institution, at Washington, who has given the results of the observations established throughout the United States and Canada, and which I have elsewhere referred to at length; and the deflection of the general direction of the mean isothermal lines of winter and summer, as given on the map, shows the modifying influences of the large masses of water in the central and western parts of Canada.

Experiments are wanting to show the temperature of the large upper lakes in winter: these would probably afford most interesting results.

Except in creeks, and small harbors and bays, these are never frozen much beyond the bordage of broken ice, which varies in width from a few yards, as in the case of deep water against bluffs, to a mile, or occasionally two miles, under circumstances favoring its accumulation; and hence it is that the cooling of large masses of water having such profundity as Lake Huron and Lake Ontario, is carried on to even a lower point than occurs in the case of the smaller lakes, and some shallower lakes, where the smaller extent of surface to be ruffled by the winds, admits of the early formation of a protective covering of ice.

Observations have been made by the officers of the United States Topographical Engineers during the progress of the lake surveys, and show very interesting results as to the temperature of the lakes: for instance, on Lake Erie, in the middle of August, 1845, the mean temperature of the air at noon was 76°; that of the water at the surface was 73°; while the temperature of the bottom was 57°, the depth of the lake being 76½ feet. In another instance, while the temperature at the surface was 71½°, that of the bottom, at 81 feet, was 58°; at double the depth, the water on the surface being 73°. Experiments were made at the end of July, 1860, midway in the lake between Cape Hurd and

Duck Islands, when it was found that while the air was 64°, the water showed 52° at surface, and 42° at 100 fathoms depth.

The fact of the existence of the cooler water being always available on Lake Ontario, has long been known to those who navigate the lakes; and advantage is constantly taken in summer of the means always within reach, to obtain a supply of cool water in a vessel let down for a few minutes to the depth of a few fathoms below the warm surface water of the lake.

## FLOODS.

Attention has been drawn to the remarkable absence of floods in the River St. Lawrence. Although those in the Ottawa are felt, yet they rarely exceed seven feet in the greatest instance, the whole basin forming an exception to the general rule of all North American rivers. In fact, taking the St. Lawrence River proper, from Lake Ontario downwards, it is most remarkable that, except under the influence of the packing of the ice (the effects of which are elsewhere explained), the floods in the river, due to freshets, are scarcely perceptible; the extreme fluctuation which generally takes place in the months of April and May being about two feet two inches above the normal level. This is, of course, due to the compensating effect of the great lakes, the area of the rivers themselves, and the uncounted lakes and swamps scattered over the whole of the basin on the slope of the northern side of the drainage area. And it is not a little remarkable that these lakes appear to be most numerous in the Laurentian system. The same feature is observable in the Adirondack region, which is also full of streams and lakes, many of which are found at seventeen hundred to eighteen hundred feet above tidewater at the head of the Moose River, and the Black River, naturally draining into Lake Ontario, at Sackett's Harbor, and lying closely contiguous to the head waters of the Scroen and Mohawk, flowing to the Hudson, and those of the Raquette, which drains into the St. Lawrence, at Cornwall.

A glance at the map will suggest the contrast which the author now begs to make in reference to the drainage of contiguous basins.

If we examine the basin of the Ohio (the southern neighbor of the St. Lawrence), draining the northeast portion of the Mississippi basin, and having its source from five hundred to one thousand feet above the level of Lakes Ontario and Erie, the dividing ridge not averaging thirty miles away from the shore of both of them, and having an area of about two hundred thousand square miles, one is struck with the remarkable contrast in its discharge. The river flows for its entire length (about nine hundred miles), in its low state with a gentle current, unintercepted by rapids, except at the Falls of Ohio, near Louisville, where there is a sudden fall of twenty-six feet in three miles; and it is during

the summer season a scanty, shallow stream, a succession of long pools and ripples, with a current alternately sluggish and rapid, with bars in the upper part of it consisting of gravel, and in the lower part of shifting sand.

The rain fall of the Ohio Valley may, perhaps, slightly exceed that over the average of the St. Lawrence Valley, as far as we have the means of calculating (the average fall over its area being, perhaps, fifteen per cent. more than that of the St. Lawrence basin); yet the range between extreme low and extreme high water is about forty-five feet throughout the river. At Wheeling, Virginia, eight hundred and ninety miles above its junction with the Mississippi, it is forty-five feet; at Louisville, forty-two feet on the Falls, and sixty-four feet below them; at Evansville, forty feet; at Paducah, fifty-one feet; and at its confluence with the great Mississippi, fifty-one feet. The usual range does not exceed twenty-five feet. The usual rise in the Ohio takes place in February, and occasionally as late as March. This arises from the melting of the snows, and generally amounting to twenty-five feet; the river remains high for about six weeks. Another rise takes place in May, or June, due to the summer rains, lasting from three to four weeks at Cairo, and from one to two at Louisville. In October, the lowest stage is obtained, when it is navigable chiefly for boats of eighteen inches draught; but in November, the river generally begins to rise, and continues to do so until the banks are full. These floods are due to the autumn rains, which are sometimes continued as late as the end of December.

The author is indebted for the foregoing information to a very valuable report, prepared by General A. A. Humphreys, of the United States Army,—a document which has been prepared with the utmost care, and which is calculated to take a prominent position in the literature of our profession relating to hydrodynamics, not only on account of the importance of the questions which are here reported upon, but also on account of the large amount of knowledge it contributes respecting the Mississippi Delta.

## FLUCTUATIONS OF LEVEL IN THE ELEVATION OF THE SURFACES IN THE GREAT LAKES.

It cannot be surprising that suppositions have been entertained as to the existence of tides upon these large masses of water; and we find in the "Relations des Jesuites," recorded in the very interesting correspondence sent to France, between 1660 and 1680, frequent references to the subject. Later than that the subject was noticed by Dr. Weld, in his travels in Canada, from 1790 to 1795, who stated that it was believed by many that the waters of Lake Ontario were influenced by a tide ebbing and flowing frequently

in the course of twenty-four hours; and he instances the fact of its rising and falling fourteen inches every four hours in the Bay of Quinte. Other writers, as well as observers, have altogether denied the latter statement, and have attributed the remarkable fluctuations which occasionally occur on Lake Ontario, and on Lake Huron, to other causes; and have not hesitated to ascribe them to partial and local changes in atmospheric pressure.

But it was impossible to dispute the fact of great fluctuations existing over a long period, the range of rise and fall in which has occupied several years to complete. And all this will be apparent by reference to a document which has been compiled by Colonel Whittlesea from undoubted facts, the greater part of them having occurred within the memory of persons still living.

The fluctuation, as may be supposed, is a matter of extreme importance to the various interests which have sprung up on the borders of the lakes, and the great rivers connecting them, but to none more than to the canal interests, as in the case of the Erie Canal, at Black Rock, the supply to which canal is derived through its uppermost reach, direct from Lake Erie, and in which the extreme fluctuations that occurred, as recently as in 1853, caused very considerable anxiety to the managers of that canal; and the relief from which was only to be found in the deepening of the whole of the canal for about twenty-two miles, the greater part of it through a limestone cutting.

As to the causes of this class of fluctuations, a great variety of suggestions have been thrown out, and, as it appears to the writer, some degree of unnecessary difficulty suggested, as to the explanation of the causes, which we should probably find little difficulty in explaining, and even of predicting the fluctuations, if suitable arrangements existed for obtaining data by a sufficiently extended series of observations upon the quantity, the rate, and the time of the fall of rain and snow, and of all the other meteorological phenomena which affect the conversion of the snow into vapor or water. It would be necessary to record the prevalence, direction, and continuance of the winds, which are observed to produce the most extraordinary effect on the surface of these lakes, and to which attention has before been called. And, lastly, should be observed the manner and the form of the taking of the ice at the outlets of these great lakes.

This latter feature appears to have been almost entirely overlooked in the suggestions which have been made to account for the increase or decrease of level in the lakes. But it will at once be apparent that the existence of a broad belt of ice over the whole surface of a rapid river, running at the rate of from three to four miles an hour, must have a great effect in regulating the discharge of that river, and so far modifying its surface. For instance, as at Fort Gratiot, at the foot of Lake Huron, where the river is about nine hundred feet wide, and usually runs at the rate of about three and a half miles per hour

(the depth being about forty-five feet), through about half a mile of its course. The river, also, for several miles below, has about double the width mentioned, and is from twenty-five to thirty-five feet deep, with a fall of about six inches per mile, producing a surface velocity of 1.45 miles per hour. The flatter surface last mentioned is generally covered with ice throughout the winter, but the rapid at the lake outlet is rarely covered more than once in five years. And under these circumstances, it will be observed that the hydraulic mean depth will be reduced from forty to forty-five per cent., by addition of the coating of irregular masses of ice forming the surface, which thus adds to the wetted perimeter, our divisor in hydraulic calculations.

The same facts have been observed to take place at the discharge of Lake Erie, near Buffalo, which is described by Major Lachlan, in the Canadian Journal, of 1854, at the breaking up of the ice of that year, as having had the effect of reducing, for forty hours, the discharge of the Niagara River, so as (according to other testimony), to have reduced the apparent discharge of the cataract by at least one-half, and on which occasion operations were carried on by the mill-owners, on the American side of the river, far out into the stream. The writer also observed, in September, 1857, a rise of two feet nine inches in the level of the water at the Ferry wharf, below the Falls, which took place in the course of one night. This result was not due to rain, nor to any other circumstance, but the continuance, for about twelve hours, of a heavy gale from the southwest, which had the effect of raising the head, and thus increasing the discharge through the rapids at Buffalo, so as to require the additional head of two feet nine inches, in the reach of the river, immediately below the Falls, to enable that deep section of the river between the Falls and the Suspension Bridge, to carry off the increased volume.

The writer by no means desires to imply that all these fluctuations in levels are to be explained by the effects of the accumulation of ice, or by its entire absence; as it is obvious that these only form one of the many circumstances which regulate the very interesting phenomena to which reference has been made.

It will be observed from the facts above stated, that notwithstanding the extensive area of these great lakes, which act in general as compensatory reservoirs, in equalizing the discharge to an almost uniform quantity; yet there are times, as before explained, when an excessive discharge, as well as the reverse action, will introduce abnormal conditions which would have to be eliminated in any calculations of actual quantity; and it may be stated, as an interesting fact bearing on this subject, that the rise of water, to the extent of one foot, on Lake Huron, for about twenty hours, in the summer of 1858, appears to have affected the discharge of the whole of the River St. Clair, the Detroit River, and the intermediate Lake St. Clair, throughout its length, the increase twenty miles down having been about seven inches, and at Detroit two and three-quarter inches: the central surface

velocity at the point first mentioned being increased from three and a quarter to six and a half miles per hour.

Up to the present time there have, unfortunately, been very few opportunities of obtaining these observations by any special scientific or professional investigation.

The fluctuations in these lakes have of late formed the subject of very careful investigation and daily observation; and ever since the establishment of the canals, records have been kept from which it is easy to describe the curves of fluctuation. Colonel Whittlesea, of the State Survey Department, at Cleveland, Ohio, has given much attention to the history of water-levels, as far back as 1788; and the results of modern observations, and of all his own inquiries, which seem to embrace everything that could be collected from trustworthy sources in the United States, are given in a very valuable memoir by that gentleman, published in the Smithsonian contributions, dated July, 1860.

But Mr. Whittlesea, like most others who had considered the probability of a tide existing in these lakes, appears to have failed to discover direct evidences of a flux and reflux that could be connected with the moon's motions.

Such observations, however, from the fitful state of the weather over the whole of this region, would require unusual attention and fitting opportunities for observations with most critical accuracy, for which is required the aid of appliances, and a residence for some time on the spot, to determine and estimate the quantities, which necessarily could only be small. And it is not surprising that those who, like Mr. George C. Davis, and Mr. Jonathan Carver (who were probably but ill supplied, in 1766, with suitable instruments for exact observation), failed to observe any diurnal flood and ebb in the upper lakes.

It remained for Lieutenant-Colonel Graham, of the United States Topographical Engineers, in charge of the works on Lake Michigan and Lake Superior, positively to affirm the existence of the truth which was first stated by him in November, 1858. Since that time the subject has been steadily occupying the attention of Colonel Graham, and of his staff; and the results are given in the report of the Topographical Bureau, for the year 1860 (dated September 30th). The course of the observations has included the recorded ordinates of a curve indicated by tide-gauges; and the discussion of these variations has included a very careful examination of exact meteorological records, in conjunction with these phenomena. The result may be stated broadly, that at Chicago, on Lake Michigan, there was a semi-diurnal spring tide of $\frac{254}{1000}$ of a foot, and a semi-diurnal mean tide of $\frac{153}{1000}$ of a foot. Similar observations conducted by Captain Meade, of the United States Topographical Engineers, show that in Lake Superior, at Superior City, the semi-diurnal spring tide is equal to 0.169 of a foot, and the semi-diurnal mean tide to .087 of a foot. This quantity is, of course, very small, and beyond a scientific interest, is of no practical

value in an engineering point of view; for the other fluctuations, arising from winds and other more apparent and proximate causes, frequently eclipse and altogether conceal them. But it is a remarkable fact; and it is believed that such fluctuations, taken in connection with exact observations upon the specific gravity of water, would tend to the solution of the problem of the moon's mass, or of her density. And it is to be hoped that, in the interest of science, similar observations may be undertaken in other lakes, in different parts of the world, where, as for instance, in the Caspian Sea, which is the largest lake in the world, and which has no regular outlet, it is believed that valuable information could be usefully collected.

## THE OTTAWA.

The Ottawa is a magnificent river, having three points of confluence with the St. Lawrence; one passing by Vaudreuil, entering at the foot of the Cascade Rapids, another by St. Anne's, at the upper part of Lake St. Louis, about twenty-four miles above Montreal, and the third opposite Varennes, thirty miles below that city. The northern stream (which flows to the north, and thus insulates the district of Montreal), bifurcates near the village of St. Eustache, and further insulates the district of Laval, known by the name of Isle Jesus. The two reuniting once more close to the lower confluence with the St. Lawrence, both branches of the river pour down their brown, peaty-colored waters, and stain the northwest side of the St. Lawrence nearly into Lake St. Peter, the blending there being favored by the various currents induced by the low alluvial islands occupying the river, which is about six miles wide (between Sorel and Berthier).

From St. Anne's, passing up the Ottawa, we pursue an almost westerly course to Ottawa, one hundred and ten miles above Montreal, where the Fall known as the "Chaudiere," interrupts the navigation: the Fall itself, with six miles of rapid water above it, having a total descent of sixty-seven feet.

In that part of the river now described, the Ottawa receives many very important affluents from the northern side, draining the front and the vast plateau in rear of the Laurentian Hills. The chief of these are the "Du Lievre," and the "Gatineau;" the latter joining close to the town of Ottawa, and having its sources as far north as the forty-eighth parallel, its head waters lying closely contiguous to the head waters of the St. Maurice and the Saguenay. A very limited extent of settlement has been carried out in this direction, and the region is comparatively unexplored and unknown,—still less surveyed; although those who have crossed it in various directions report it as being filled with uncounted lakes, which regulate the annual supply to the rivers of the whole of this vast region.

The affluents on the south side are the Petite Nation, and the Rideau Rivers; the head

waters of the former draining back into the country, within nine miles of the main stream of the St. Lawrence, at Prescott, where its head water is forty-nine feet above it, and about ninety feet above its confluence with the Ottawa. The line of the main channel of this small stream extends its tortuous course through deep alluvial soil, for upwards of a hundred miles, passing through and producing swamps which have the same effect, to a certain extent, as the lakes on the northern side. The Rideau River has proportionately a very large drainage area, filled with lakes and streams flowing chiefly from, and determined in outline by the outcrop of the Laurentian formation, which has been described as sweeping down from the Chats Falls to the Thousand Isles, near Kingston.

Above Ottawa there is rapid water extending for upwards of six miles, and from this point the stream, although less direct, passes on in the direction of the northwest, over and through a wilder country of the Laurentian Hills, with heavy forests of pine and other timber extending down to its very margin. The irregular and tortuous channel, swelling occasionally into deep, wide lakes, terminates immediately above Allumette Island; and from this point the river, taking a slight bend once more in a west-northwest direction, pursues its course through a series of long reaches, separated from one another by short, abrupt falls or rapids, with a tolerably uniform width and depth, as far as the affluence of the Mattawan; then turning to a direction almost northward, it is described as terminating in a series of lakes, the largest of which, in the direct course of the river, is "Temiscaming," "Tamagaminque," and "Grand Lake;" the one lying some distance to the west, and the other about as far to the east of Temiscaming, pouring their waters into it by the "Montreal" and "Moose" Rivers respectively, and the drainage occupying the whole district lying as far north as the forty-ninth parallel, and generally separated from the drainage into the river below Ottawa by the meridian of seventy-six and a half degrees. The affluents upon both sides of the river, for the portion west of Ottawa, are much more numerous, and are all very much smaller than the streams previously mentioned. On the north side they consist of the "Colonge," uniting close to Portage du Fort, the "Du Moine," the "Bear," and the "Kippeway." On the south side, the chief of these streams are the Mississippi, the Madawaska, the Bonne Chère, the Petawawee, and the Mattawan. These drain a vast extent of Laurentian formation, covered for the most part with heavy pine timber, the district of the chief lumbering operations in Canada at the present moment. The country is very much broken, and the bottoms of its valleys and creeks are occupied by numerous streamlets and lakes lying at elevations extending up to fourteen hundred feet above tidewater; at which elevations may be found the sources of the streams last mentioned, draining into the Ottawa, and the head waters of the Maganatawan, flowing into Lake Huron.

One tributary, on the right bank of the river, unites with the main Ottawa, at Matta-

wan, the point of northern divergence just mentioned; and it is important as being the favorite route of the early voyageurs in their journeys to Lake Huron and Lake Superior. Starting from the Hudson's Bay Post, at its confluence with the river, the Mattawan is traceable in a course generally westerly, through five or six small lakes, terminating in Trout Lake, which is the head of the drainage in this direction, and about six hundred and fifty-nine feet above the sea.

Among the various schemes which have been proposed for the improvement of the navigation between the upper lakes and the Atlantic, that of Mr. Shanly, which is gaining (and perhaps deservedly) the most favor, is one which proposed, after improving the River Ottawa, up to the mouth of the Mattawan, to follow the line of this tributary up to its head water in the Trout Lake. From this point it is proposed to lock down into Lake Nipissing, which is only about twenty-three feet below it, through the valley of the "Vase." Lake Nipissing, which receives the drainage of the "Sturgeon," the "Namanitigong," and other rivers, with that of numerous lakes, at their several head waters, communicates with the Georgian Bay, through French River; the length of the river being about sixty miles, and the descent, effected in a series of weir-like falls, sixty-four feet.

The entire distance from the Georgian Bay to Montreal, by the route which has now been described (and which, of course, includes improvements of the river to overcome the falls at Ottawa, the Chats, and other points of interruption, as well as the reconstruction of the small canal near Carillon and Grenville), being four hundred and thirty miles. The lockage upwards from Lake Huron to the summit would be eighty-seven feet, and the fall downwards would be six hundred and nineteen feet, to the harbor of Montreal.

And having now generally referred to this enormous river, a full description of which might have occupied a far more extensive space,—and having mentioned the proposal to improve the water communication, by a more direct route, between the upper lakes and the Atlantic, it is only proper to draw attention to another project, with the same object in view. This consists of a canal commencing at the level of Lake Huron, near Nottawassauga Bay, passing through part of the Valley of the Muskoka and of the Severn, which constitute the drainage of Lake Simcoe, into Georgian Bay. It is proposed to make Lake Simcoe, which is one hundred and thirty feet above Georgian Bay, the summit level; and cutting through the dividing ridge, to a depth of two hundred feet, lock down its southern slope, four hundred and seventy feet, into Lake Ontario, near Toronto. With regard to both of these plans, however, little has been done beyond preliminary surveys. The expenditure by the last-named route is estimated at $24,000,000; that by the Ottawa route at about the same amount, including the further widening of the Lachine Canal.

Taking Chicago and Montreal as common points, and comparing both with the Welland Canal, the following would be the position of affairs:

| | DISTANCES FROM CHICAGO. | | | | LOCKAGE. | | |
|---|---|---|---|---|---|---|---|
| | Miles. Lake. | Miles River. | Miles. Canal. | Miles. Total. | Up. | Down. | Total. |
| No. 1. Welland Canal, Lake, and River, . . | 1,145 | 132 | 71 | 1,348 | | 535 | 535 |
| " 2. Toronto and Georgian Bay, . . . . | 775 | 155 | 120 | 1,050 | 130 | 675 | 805 |
| " 3. French River and Ottawa, . . . . | 575 | 347 | 58 | 980 | 87? | 619? | 706 |

From which figures it appears that in point of distance No. 3, namely, by the Ottawa, holds a very wide advantage over both the rival routes, and is also superior, in point of lockage, to the Georgian Bay route. And if constructed, it would be yet more important in a sense which just now would seem to be of the greatest consequence, namely, the national consideration. For a glance will show that the communication with the West would no longer occupy almost the very line of the frontier between the United States and Canada, through a considerable portion of the route; and where the locks of the canal, which are such important and vulnerable points, approach so near to American territory.

## CANALS OF CANADA.

The system of canals which were exclusively undertaken, or are controlled, by the Provincial Government of Canada, consists of a series of works for overcoming the Rapids, on the line of the main discharge of the waters of the upper lakes through the St. Lawrence Valley; secondly, in improvements of the same nature applied to the Ottawa River; thirdly, in a connection effected by a cross canal between the Ottawa River and the city of that name, with the River St. Lawrence, at Kingston, which is at the outlet of Lake Ontario; fourthly, of improvements on the Chambly, or Richelieu River, which is the outlet of Lake Champlain. There is, also, a series of minor improvements in the form of locks, or very short canals, in the district occupied by the line of lakes extending almost parallel with the north shore of Lake Ontario, from Lake Scugog by way of Peterboro' and the Trent River to Trenton, at which place the Trent discharges into the lake.

As for the purposes contemplated in the present contribution to the information of the Society, it would far surpass any reasonable limits, to describe with the requisite full engineering details, each canal with its peculiarities. An attempt has been made to tabu-

late, and to offer in one view a statement, with all the leading features which are likely to render this paper of interest and value; and a broadside sheet marked 12, was prepared, intended to give under the head of details of construction, first the name and object of each work, the dates of its commencement and completion, the total cost up to January, 1861, the nature of the supply of water, the length with a diagram of the cross section of the canal, as constructed, the number, the length, the cross section and the lift of all the locks, with particulars of minimum structure. Under the next head was shown the working capabilities of the canal, with the limits of the length, beam, and draft of vessels that can pass the locks, the time of transit at each lock, and for the entire passage of the canal, and the number of working days on the average in the year. And under the head of traffic was given the number of vessels up and down; the number of tons carried up and down; the particulars of the haulage, how performed, and the cost; the total revenue of the canals, and the expenses of repairs and maintenance; the tolls per ton, and the total amount of tolls charged.

The first of these great improvements was commenced about the year 1819, by a private company, which undertook the construction and completion of the Lachine Canal, which proposed to overcome the Rapids from Lake St. Louis down to Montreal, the total length of fall being four thousand three hundred and seventy-five feet.

This canal commenced in the St. Lawrence River, at a place called Windmill Point, and near the upper end of the present harbor, at Montreal. One of the original locks still remains at this point, and the dimensions are one hundred and twenty-six feet by twenty-four.

The line proceeds across a marsh for about four miles, and eventually passes into more solid ground, and terminates in a rock of the Trenton group at Lake St. Louis. The number of locks originally was *nine*.

Following this great improvement, which at once overcame the most considerable difficulties in the inland navigation, some improvements were commenced on the River Ottawa, consisting first, of the St. Anne's lock and dam, to overcome the Rapids of St. Anne, at the entrance to the Ottawa River, about twenty-four miles west of Montreal.

The length of the entire work is about half a mile, and the fall, which is on the average about three and a half feet, is overcome by one lock one hundred and ninety feet long and forty-four feet wide. At Carillon there is a small lockage, consisting of two combined locks rising twenty-three feet to pass over a small summit (the cost to cut through which was considered too expensive), and one single descending lock 12.93 feet; so that the actual fall surmounted at this point is only about ten feet. The length of the canal is about $2\frac{1}{10}$ miles. The Chute à Blondeau is the next canal, and closely contiguous to the former one; its length being about one-sixth of a mile, overcome by one lock surmounting

a lift of three feet ten inches. The Grenville Canal, still further up stream, is a canal having the same object, five and three-quarter miles in length, having six locks, overcoming a lift of forty-six feet: the total lift for the three canals being 72.88 feet ascending, descending 12.93 feet, or 59.95 feet.

All locks upon the system last mentioned have a depth of five feet upon the sills, are one hundred feet long, nineteen feet wide, and were constructed before the year 1833.

The Rideau Canal, of which there is a very full description given in an elaborate paper by Lieutenant Frome, late of the Royal Engineers, in the R. E. papers, is a work of considerable importance, and was constructed at a very large cost by the British Government. It was commenced about the year 1826, and completed about 1831. Its supply of water is from the Rideau Lake, from which lake the river flows in a general northeasterly and southwesterly direction. The length of the canal is about eighty-four and a quarter miles. Its cross section is forty-eight feet wide at the top, twenty-eight feet at the bottom, with five feet depth of water. There are thirty-three locks, one hundred and thirty-four feet long, thirty-three feet wide, and the depth on the sills is five feet. The greatest lift is fourteen feet six inches. With regard to the construction of the canal, it was carried on under the direction of Colonel By, whose name first characterized the locality of the city which has been chosen as the future seat of government in Canada.

The paper to which allusion has been made will have afforded to engineers some interesting information, and an account of difficulties of no common occurrence. It is to be regretted that the course of trade, which of late years has rather tended by the more direct route up the St. Lawrence, has appeared to demand less of that attention to the maintenance of the works on this navigation than its importance in a national point of view seems yet to demand.

Details of the traffic carried on this canal, are given in the trade and navigation returns of Canada, by which it will be seen that the traffic through this district is of very considerable importance. The works now described would include all the works undertaken up to about the year 1819; and previous to which time, the attention of the authorities in the State of New York was directed to the importance of bringing down a line of canal connecting Lake Erie with the tidewater navigation at Albany, a work which was proceeded upon with great alacrity, and completed with that degree of energy, which appears to characterize the people of the Northern United States.

To this canal, and its works, reference is made in another place. The effect on the minds of the public men in Canada was immediately to provide for the carrying out of a work, which is the most important of all those that have occupied the attention of the public in Canada, namely, the construction of the Welland Canal. This work intersects

the barrier which separates, and maintains the difference of level between Lake Erie and Lake Ontario, the natural discharge of the former being by Niagara River and Cataract.

The work consists of a reach of canal extending from Lake Erie to the head of a series of lockages overcoming a lift of three hundred and thirty-one feet, which, as shown in the section, are grouped rather closely together on the rapid descent through the villages of Thorold, St. Catharine's, and Port Dalhousie. The entire length of the canal is twenty-eight miles, in addition to which there is a feeder of twenty-one miles in length, derived from the Grand River, which is dammed up to the extent of seven feet, for the purpose of affording a steady supply of water, as well as of avoiding an expensive difficulty in construction by extending the depth of the excavation, which has been a constant source of trouble, but it was, perhaps, the more desirable, in consequence of the extreme fluctuations which take place in the level of Lake Erie. The chief work upon this canal is the Summit Level Cutting, cut through the Niagara limestone, which has caused very considerable difficulty by slips and slides. The locks, twenty-four in number, are one hundred and fifty feet long, twenty-six feet six inches wide, and vary from fourteen feet to nine feet lift. The capabilities of the canal admit of vessels one hundred and forty-two feet long, twenty-six feet beam, and ten feet draft. There is also a work connected with this, called the Welland Feeder, extending to Dunville, and the Broad Creek Branch, connecting the last-named feeder with Port Maitland. The Welland Feeder has the same width at top and bottom as the main canal, viz., seventy-one feet at top, and thirty-five feet at bottom, and has eight feet depth; while the Broad Creek Branch has ten feet depth, and in width is eighty-five and forty-five feet respectively at top and bottom. The locks are built of stone, and the whole work, which is under the able control and management of the Hon. H. H. Killaly, Commissioner of Public Works, has received every attention and appliance for facilitating and economizing the transit of the very heavy traffic of which it is the medium.

*The Lachine Canal*, as before described, was started in the year 1819, upon the limited width described, but in the year 1833, after the fullest attention given to the subject by the Provincial Government, a new system was begun, which proposed to construct works up the line of the St. Lawrence, capable of passing sea-going vessels, and large steamers, suited to the navigation of the upper lakes. And the important works which followed, including the reconstruction of the Lachine Canal, are quite worthy of the age in an engineering point of view.

The Lachine Canal has been widened and deepened, to one hundred and twenty feet width at top, eighty feet at bottom, and ten feet in depth. The terminal points, and the length (which is eight and a half miles) are the same. The locks, which are four in

number, are forty-two feet three inches wide at the lower level, and forty-five feet across at the top-water surface. The maximum lift is thirteen feet, the minimum eight and three-quarters feet. Vessels of one hundred and eighty-five feet length, forty-four feet beam, and nine feet draft, are the limits of capacity.

The navigation from the head of the Lachine Canal upwards passes through Lake St. Louis, and crosses over to the southeast side near the upper end of the lake, to enter the Beauharnois Canal, which is the next work. It connects Lake St. Francis with that of St. Louis, at the foot of the Cascade Rapid, and this canal avoids also the Cedars and Coteau Rapids. The length of the canal is eleven and three-quarters miles. Its width at top-water is the same as that of Lachine. The locks are nine in number, two hundred feet long, forty-five broad at top-water, forty-three and a half feet at the lower water surface. The greatest lift is eleven feet, the least eight feet, and the same class of vessels navigate it as pass the Lachine Canal; it is the only canal which takes the south side of the river,—the mean distance from the American frontier is twenty-five miles.

Passing up stream through Lake St. Francis, we arrive, at a distance of sixty-three miles from Montreal, at the foot of the Cornwall Canal, which is eleven and a half miles long, and surmounts the Long Sault Rapid, which has a total fall of forty-eight feet. The width of the canal is one hundred and fifty feet at top and one hundred feet at bottom, with a depth of ten feet. It is principally formed by reclaiming out of the space originally occupied by the river and its bank, sufficient space for the formation of the cross section described.

It may be as well to remark that the centre of the river from this point onwards, is the dividing line between Canada and the United States, the line of forty-five degrees north latitude striking the River St. Lawrence at St. Regis, a short distance below the lower end of this canal. And it is interesting to observe the small width of the river near this point, as shown on an enlarged plan, and that the narrowest width between United States territory and the Canadian shore is about six hundred feet, measured between the northwestern side of Croiles Island and the canal bank. The locks on this canal are two hundred feet long, fifty-five feet on the top of the walls, and fifty-three and a half feet at the lower level.

The Williamsburg Canal, consisting of four short canals, the last of these so-called St. Lawrence Canals, commences at eighty-nine and a half miles above Montreal, and was constructed to avoid the Farren's Point, Rapid Plat, Point Iroquois, and Galops Rapids, which have a total fall of twenty-nine and a half feet. With the construction of these canals was completed, in 1847, the last link of this great inland system. Their aggregate length is nine and three-quarters miles; their cross section is ninety feet top, fifty feet bottom, and ten feet deep. There are six locks two hundred feet long, forty-five feet wide

at top—forty-three and a half feet at low water. The lift of these locks is eleven and a half feet maximum, three and a half feet minimum.

All these St. Lawrence Canals admit of vessels having an extreme length of one hundred and eighty-five feet, forty-four feet beam, and nine feet draft; but the Cornwall Canal would admit of the passage of vessels with fifty-three feet beam.

The traffic on this part of the river consists of through passenger traffic, which usually assumes some importance about the first week of July, and continues until about the middle of September. The vessels engaged in this traffic are lake-going steamers, which run in connection, more or less, with some of the railways on both sides of the lake, and either in close connection, or in violent competition, with the railways for the through traffic in passengers, which it may be here stated, in the course of the summer can be barely remunerative to either system of transit. The steamers have, usually, side wheels; are very lightly built, having a draft not exceeding six feet; and they perform the distance from Toronto to Kingston, about one hundred and seventy miles (usually by night), in fourteen hours; and from Kingston to Montreal, shooting all the Rapids, in about thirteen hours, the distance being one hundred and seventy-five miles.

This route, which is a highly popular one in the country, and taken by all the strangers who visit, is very attractive through a certain degree of hazard and interest which is attached to the "shooting of the Rapids." This matter has been so frequently described, that it will be unnecessary to offer further comment than will be suggested to any practical mind, and it is believed that few, after seriously thinking over the subject, would venture to recommend the passage of a vessel two hundred feet long, of the flimsiest construction, down a rapid tortuous channel, frequently much less than two hundred feet wide, filled with rocks and boulders of enormous size, and with currents, eddies, and slackwater, as embarrassing as it is possible to conceive of in any navigation.

The traffic of the kind mentioned has been only estimated; exact statistics cannot be obtained; but until within the last three years, the boats were constantly crowded with passengers for three or four months in the year.

It need scarcely be added that the boats return to the point from whence they came by the canals, upper river, and lake, and that they depend for their subsistence chiefly upon the western bound freight in merchandise from Montreal, the chief city of commerce in Canada. The most extensive and important business is carried on by screw propellers, as well as by lake and river schooners, scows and barges. Towing is performed for the most part by steamers.

The water communication between Montreal and the State of New York is carried on by rather an indirect line of navigation, down the River St. Lawrence to the embouchure of the Richelieu, forty-five miles below Montreal, and about one hundred and thirty-five

miles above Quebec. At Sorel, the direction of the route is a little to the west of south. The river has an average rate of about a mile and a half per hour, and in low stages of the river it occasionally runs at the rate of four miles an hour in certain localities; besides which, at St. Ours, there is a decided rapid, having a fall of five feet, where a lock and dam have been introduced, the dimensions of which admit of vessels one hundred and eighty-five feet long, and forty-four feet wide, with a draft of seven feet, and at Chambly another rapid exists, amounting to a seventy-four foot fall, extending through eleven and a half miles of the river. This rapid is overcome by a canal and nine locks, the dimensions of the canal being sixty feet top-water, thirty-six feet at bottom, and eight feet depth; and the locks are one hundred and twenty feet long, twenty-four feet wide at top, and twenty-two and a half feet at low water, and will admit of vessels one hundred and ten feet long, twenty-two feet wide, and seven feet draft. The navigation, which extends up to Lake Champlain, which is reached at about eighty miles from Sorel, meets with no further obstacle, and is continued free through Lake Champlain to the New York Champlain Canal, at Whitehall, where it has only to overcome a height of fifty-five feet before commencing to fall to the tidewater of the Hudson, at Troy.

## IMPROVEMENTS TO THE NAVIGATION OF THE INLAND WATERS OF THE NEWCASTLE DISTRICT.

Above the town of Peterboro, the Otonabeo, for some miles, maintains the character of a fine river, nearly two hundred feet wide, discharging a large supply of water at all seasons, and affording admirable sites for factories requiring large power. The river there spreads out into a number of lakes, which are the recipients of several considerable streams: some of these navigable, and some, it is stated, capable of being made so at a very small cost. The connection with this district is of considerable importance, on account of the large quantity of timber abounding in that section, and the valuable nature of the country for agricultural purposes. Some improvements have been commenced, but no very extensive or permanent works executed. Improvements in the Scugog River have been carried on, and a dredging engine employed for the deepening of shoal places. The value of the several reaches of continuous water communication may be considered as created by these limited works, and daily become more manifest. They extend through a distance not less than one hundred and thirty miles; and when the various improvements proposed have been carried out, a great benefit will be extended to a large district of country.

Among the collateral advantages which have been afforded by the construction of the various canals in Canada, is that afforded by their water power, by means of which the

Provincial Government has been enabled to offer encouragement to manufactures on canal banks; and arrangements were made, in the first instance, for a considerable supply of water for manufacturing purposes, which, in several instances, has been carried to a very great and injurious limit: as, for instance, on the Lachine Canal, the velocity in which has become a serious inconvenience to the traffic; so much so, that a large expenditure has been rendered necessary during the present winter, for the enlargement of the cross section through the rock cutting already mentioned near Lachine.

## WHARVES AND CRIBWORK.

Having now described the leading public works which have been undertaken in the Provinces, in connection with the navigation of the St. Lawrence, the description would be incomplete if there was any omission of the numerous wharves which have been established upon the various rivers and lakes extending from the lower St. Lawrence upwards. These wharves, in consequence of the great cost, and the difficulties attending the construction of masonry in such localities, have been for the most part built of what is locally known on the continent of America as "cribwork;" and as the work seems to be almost peculiar to this side the Atlantic, and almost unknown on the other, it may be proper to give a description of the character of the work; and to render this clear, some sketches are appended of cribwork, which may be considered fair examples of the ordinary mode of construction. It will be perceived that this cribwork consists of a heavy grillage, or framework of whole timbers, treenailed and dovetailed into each other. The work is put down in sections, and is built floating in the water, and having been brought into the intended site, it is loaded with stone, which, acting as ballast, settles it into its place. After finally adjusting the cribwork to its proper position, stone is added to give weight and stability to the mass, which may be taken as having a specific gravity as compared with water of one and eight-tenths. This cribwork is found to be much more durable than could have at first been supposed, there being wharves now standing in the tideway at Quebec which are said to have been built upwards of eighty years ago. Many of the wharves built in the rivers of Canada and the United States are in the form of jetties, projecting at right angles to the shore, where they are exposed to very severe pressure from the floating bordage ice. And although there are some instances which could be quoted of cribwork being moved by the ice, it was generally to be traced to the want of stone ballast, which is the chief point to be attended to in the construction of these works.

The timber employed is of all kinds, although pine culls, as they are called (which is a third class timber), is chiefly used, in logs of all sizes, and of all lengths.

The average cost of cribwork at Montreal is $1.75 per cubic yard; at Quebec it has

been done for about $1.10; and in Western Canada, $2.00. In all cases, the work was in deep water; and in the case of Quebec, it varied from twenty-eight to thirty-eight feet in height.

The attention of the writer has been drawn to one of the effects of ice, which has not yet been mentioned, and that consisting in the expansion of large unbroken fields of ice, and which has produced the most serious injury to public works.

The line of the Cobourg and Peterboro' Railroad crosses over Rice Lake about ten miles north of Lake Ontario, by a bridge of nearly three miles in length. The lake is about eighteen miles in length, and obtains its maximum width at the point of crossing, and is about twelve feet deep. Early in the season, this lake becomes covered with ice, which occasionally increases to a thickness of two feet.

The bridge or viaduct, for about five-eighths of its length, consists of a series of short spans, of from twenty-five to thirty-five feet clearance, each resting upon blocks of cribwork, about fifteen feet square. The remainder consists of larger spans, some of them extending to even seventy feet opening.

The effect of the expansion of ice has here been felt, and for a few years after its construction the most serious injury was done to the structure. The cribwork in many cases was turned on one side, the whole line moved out of range, and the railway itself was rendered almost impassable.

To obviate, or rather to mitigate this mischief, the engineer ploughed a groove through the ice, on each side of the bridge: the result of which was, that in thus finding the line of least resistance, the ice was broken up, and the pressure greatly reduced. The mischief, however, could not be wholly repaired, and the company has been engaged for the last four years in filling up the lake along the line, thus forming an embankment of earth.

Cribwork is most extensively employed on all the canals, wharves, railways, and other structures of the country.

# TABULAR STATEMENT

## OF THE LEADING PARTICULARS OF THE PRINCIPAL LAKES REPORTED ON.

| NAME. | DISTRICT. | GEOLOGICAL POSITION. | HEIGHT ABOVE SEA. | AREA. Sq. Miles. | DIRECTION OF DRAINAGE. | AUTHORITY FOR PARTICULARS. |
|---|---|---|---|---|---|---|
| Superior, | Canada and United States. | Laurentian, Huronian, and Lower Silurian. | 601 | 31,420 | Southwards into Lake Huron. | Logan, Bayfield, Shanly. |
| Michigan, | Michigan, Illinois, and Wisconsin. | Lower, Middle and Upper Silurian, and Devonian. | 575 | 25,590 | Eastward through Straits of Mackinaw to L. Huron. | U. S. Top. Engineers, Bayfield, Houghton, Logan. |
| Huron, | Canada and Michigan. | . . . . | 575 | 23,780 | Southwards by River and Lake St. Clair and Detroit River to Lake Erie. | U. S. Topog. Engineers, Bayfield, Logan, Shanly, Tully, Houghton. |
| St. Clair, | Canada and Michigan. | Upper Silurian and Devonian. | 570 | . . . | Intermediate. | . . . . |
| Erie, | Canada, Michigan, Ohio, Pennsylv'a, New York. | Upper Silurian. | 565 | 10,030 | Southeastwards via Niagara River into L. Ontario. | Bayfield, U. S. Top. Engineers, Logan, Hall. |
| Ontario, | Canada and New York. | Lower Silurian. | 234 | 7330 | Northeastwards into River St. Lawrence. | Bayfield, Logan, Shanly, Canadian Bd. Works. |
| Lakes U. S., Adirondack Mountains, Moose River, Middle Branch. No. 8, | State of New York, Northern part. | Stated to be in the Potsdam sandstone and Laurentian gneiss, with limestones. | 1776 | 309 | By Moose & Black Rivers into Ontario at Sackett's Harbor, and artificially through the Erie Canal to the Mohawk River and Hudson. | Surveyors and Engineers of the New York State Canals. |
| " 7, | | | 1762 | 609 | | |
| " 6, | | | 1760 | 53 | | |
| " 5, | | | 1691 | 9 | | |
| " 4, | | | 1687 | 1979 | | |
| " 3, | | | 1684 | 166 | | |
| " 2, | | | 1684 | 175 | | |
| " 1, | | | 1684 | 403 | | |
| Forks with South Branch, | | | 1487 | . . . | | |
| Memphramagogh, | Eastern Townships. | Lower Silurian and Quebec group. | 756 | 37 | By Magog River into St Francis, at Sherbrook. | . . . . |
| Aylmer, | . . . . | . . . . | 795 | 9 | St. Francis. | Geological Survey. |
| St. Francis, | . . . . | . . . . | 890 | 12 | St. Francis River to St. Lawrence at L. St. Peter. | . . . . |
| Megantic, | Eastern Townships. | Qy. Quebec group. | . . . | . . . | Via Chaudiere R. to St. Lawrence, near Quebec. (Not in drainage area of St. Lawrence. | . . . . |
| Temisconata, | Lower Canada. | Qy. Quebec group and Lower Silurian. | 467 | 24 | Discharge by the Madawaska into St. John at Lit. Falls | . . . . |

| NAME. | DISTRICT. | GEOLOGICAL POSITION. | HEIGHT ABOVE SEA. | AREA. Sq. Miles. | DIRECTION OF DRAINAGE. | AUTHORITY FOR PARTICULARS. |
|---|---|---|---|---|---|---|
| Lake Huron, | Northwestern district of Canada. | For the most part in the Laurentian and Lowest Silurian. | 578 | . . . | Draining into Lake Huron. | Surveys of Canada. |
| Island Lake, | | | 677 | . . . | | |
| Wahwaskesh, | | | 714.81 | . . . | | |
| Maple, | | | 789 | . . . | | |
| Aumick, | | | 898 | . . . | | |
| Shesheep, | | | 918 | . . . | | |
| Doe, | | | 953 | . . . | | |
| Burnt, | All these are in the western side of the watershed in the district lying north of Ontario, south of the French River, and east of the Lake Simcoe drainage. | Chiefly in the Lower Silurian and Laurentian. | 1405 | . . . | Drain into Lake Huron, within Georgian Bay. | Geological Surveys of Canada. |
| Canoe, | | | 1384.85 | . . . | | |
| Ox Tongue, | | | 1253 | . . . | | |
| Lake of Bays, | | | 1109 | . . . | | |
| Peninoula, | | | 1007 | . . . | | |
| Fairy's, | | | 1001 | . . . | | |
| Mary's, | | | 993 | . . . | | |
| Muskoka, | | | 790 | . . . | | |
| Lake Huron, quoted, | | | 578 | . . . | | |
| Confluence of Pettawawee with Ottawa at L'Allumette, | Western Canada, occupying the country now chiefly available for the production of the lumber for Canadian exports. | These lakes are for the most part in Drift or in the oldest Silurian rocks and Laurentian formation. | 437 | . . . | All these drain into the Ottawa, above Lac des Chats. | Geological Surveys of Canada, under direction of Sir W. E. Logan and assistants. |
| Traverse, | | | 721 | . . . | | |
| Trout, | | | 929.5 | . . . | | |
| Cedar, | | | 1050 | . . . | | |
| Catfish, | | | 1290 | . . . | | |
| Burnt Lake and Red Pine, | | | 1320 | . . . | | |
| White Trout, | | | 1336 | . . . | | |
| Otter Slide Lake, headwaters of Pettawawee, | | | 1405.85 | . . . | | |

| NAME. | DISTRICT. | GEOLOGICAL POSITION. | HEIGHT ABOVE SEA. | AREA. Sq. Miles. | DIRECTION OF DRAINAGE. | AUTHORITY FOR PARTICULARS. |
|---|---|---|---|---|---|---|
| Rideau, . . . . . . . . . | Upper Canada. | Lower Silurian and Laurentian. | 400 | . . . | Via Rideau River into Ottawa, at Bytown. | Canadian Surveys. |
| Simcoe, . . . . . . . . . | Upper Canada. | Lower and Middle Silurian. | . . . | . . . | . . . . | . . . . |
| Lac des Chats, . . . . . . | Upper Canada. | Laurentian and Lower Silurian. | 410 | . . . | . . . . | . . . . |
| Balsam, . . . . . . . . . | Upper Canada. | | 820 | . . . | | |
| Cameron, . . . . . . . . | Upper Canada. | Middle and Lower Silurian and Laurentian and Drift. | 815 | . . . | Via Otonabee and Trent to Ontario. | . . . . |
| Sturgeon, . . . . . . . . | Upper Canada. | | 793 | . . . | | |
| Pigeon, . . . . . . . . . | Upper Canada. | | 788 | . . . | | |
| Salmon Trout, . . . . . . | Upper Canada. | . . . . | 758 | . . . | Via Mattawan to the Ottawa. | . . . . |
| Rice, . . . . . . . . . . | Upper Canada. | Middle Silurian and Drift. | 596 | . . . | Via Trent to Ontario. | Shanly and others. |
| Belmont, . . . . . . . . . | . . . . | . . . . | 599 | . . . | . . . . | . . . . |
| Scugog, . . . . . . . . . | . . . . | . . . . | 797 | . . . | . . . . | . . . . |
| St. Francis, . . . . . . . . | Lower Canada. | Lower Silurian. | . . . | . . . | St. Lawrence River. | Bayfield, Public Works' Office. |
| St. Louis, . . . . . . . . . | Lower Canada. | . . . . | 57 | . . . | St. Lawrence River. | . . . . |
| St. Peter, . . . . . . . . . | . . . . | Lower Silurian. | . . . | . . . | St. Lawrence River. | . . . . |
| Lake Champlain, . . . . . | Northern New York and Western Vermont. | Lower Silurian and Potsdam sandstone. | 95¾ | . . . | By Richelieu and Chambly to St. Lawrence. | U. S. Engineers. |
| Lake George, . . . . . . | Northern New York. | Low'r Silurian, Potsdam sandstone & Laurentian. | 325 | . . . | Via Ticonderoga Falls into Lake Champlain. | U. S. Engineers. |
| St. John, . . . . . . . . . | Saguenay. | Laurentian. | 300 | 360 | Saguenay River. | Geol. Survey of Canada. |
| Grand Lac, . . . . . . . . | Northwest Canada. | | 700? | 560 | . . . . | . . . . |
| Temiscamang, . . . . . . | Northwest Canada. | Laurentian and Lower Silurian. | 126 | 612 | Into Nipissing. | Shanly. |
| Keepawa, . . . . . . . . . | Northwest Canada. | | 760 | 92 | . . . . | Logan. |
| Temagaming, . . . . . . . | Northwest Canada. | Laurentian. | 800 | 330 | Via Nipissing into French River. | Shanly, Murray. |
| Nipissing, . . . . . . . . | Northwest Canada. | Laurentian and Silurian. | 639 | 294 | Via French River to Lake Huron. | Logan, Shanly. |

## AGGREGATE OF LOSSES AND DISASTERS ON THE LAKES AND ST. LAWRENCE,

### IN STEAMERS AND SAILING VESSELS, INCLUDING THE LOSS AND DAMAGE OF CARGO, FOR THE YEARS 1848 TO 1855, BOTH INCLUSIVE (BEING 8 YEARS).

| Manner of Loss. | Steamers. | | Propellers. | | Barques. | | Brigs. | | Schooners. | | Scows. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. |
| Wrecked and Sunk, . . | 25 | $914,500 | 19 | $903,000 | 15 | $231,500 | 31 | $345,600 | 182 | $1,100,226 | 7 | $12,600 |
| Stranded, . . . . . | 52 | 305,150 | 35 | 98,050 | 14 | 18,200 | 82 | 118,500 | 377 | 515,370 | 11 | 6,850 |
| Fire, . . . . . . . | 19 | 492,600 | 8 | 222,800 | | | | | 10 | 47,300 | | |
| Damaged, . . . . . | 108 | 385,500 | 92 | 361,150 | 35 | 87,900 | 160 | 222,375 | 444 | 644,334 | 29 | 15,975 |
| Jettison, . . . . . . | 4 | 39,500 | 19 | 83,500 | 3 | 9,000 | 9 | 28,500 | 46 | 80,280 | 2 | 600 |
| Collision, . . . . . | 67 | 286,000 | 54 | 747,440 | 9 | 65,700 | 43 | 152,950 | 102 | 270,300 | 2 | 2,300 |
| Sunk and Raised, . . . | | | 1 | 100,000 | | | | | | | | |
| Derrick, . . . . . . | | 20,000 | | | | | | | | | | |
| Flood, . . . . . . . | | | | | | | | | | 25,000 | | |
| | 275 | $2,443,250 | 228 | $2,515,940 | 76 | $412,300 | 325 | $867,925 | 1161 | $2,682,810 | 51 | $38,325 |

| Total | No. | Value. |
|---|---|---|
| Steam disasters, | 503 | $4,959,190 |
| Sailing vessel disasters, . . . | 1613 | $4,001,360. |

## AGGREGATE OF LOSSES AND DISASTERS ON THE LAKES AND ST. LAWRENCE,

IN STEAMERS AND SAILING VESSELS, INCLUDING THE LOSS AND DAMAGE OF CARGO, FOR THE YEARS 1856 TO 1861, BOTH INCLUSIVE (BEING 6 YEARS).

| Manner of Loss. | Steamers. | | Propellers. | | Barques. | | Brigs. | | Schooners. | | Scows. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. |
| Wrecked and Sunk, . . | 27 | $362,650 | 30 | $972,760 | 15 | $154,650 | 22 | $145,850 | 179 | $1,392,048 | 54 | $193,650 |
| Stranded, . . . . . | 39 | 118,455 | 83 | 317,770 | 39 | 215,343 | 76 | 211,050 | 503 | 1,336,644 | 47 | 48,023 |
| Fire, . . . . . . . . | 17 | 435,000 | 24 | 370,600 | | | 1 | 450 | 4 | 9,550 | 1 | 1,200 |
| Damaged, . . . . . | 97 | 175,675 | 151 | 165,740 | 79 | 98,830 | 75 | 50,485 | 551 | 409,419 | 33 | 18,000 |
| Jettison, . . . . . . . | 5 | 16,300 | 13 | 67,755 | 3 | 5,764 | 8 | 17,000 | 68 | 72,584 | 4 | 360 |
| Collision, . . . . . | 41 | 149,210 | 58 | 174,325 | 29 | 21,085 | 37 | 83,950 | 235 | 459,546 | 12 | 8,462 |
| | 226 | $1,257,290 | 359 | $2,068,950 | 165 | $495,672 | 219 | $508,785 | 1540 | $3,679,791 | 151 | $269,695 |
| | Total | | No. | Value. | | Total | | | | No. | Value. | |
| | Steam disasters, | | 585 | $3,326,240 | | Sailing vessel disasters, . . . | | | | 2075 | $4,953,943. | |

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | THERMOMETER. | | | | Daily Mean. | 1861. | Temp. of | THERMOMETER. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JANUARY. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | FEBRUARY. | Water. | 9 A.M. | Noon | 3 P.M. | 6 P.M. | |
| 1 | 31.0 | 23.5 | 24.0 | 26.0 | 25.0 | 24.60 | 1 | 31 | 20.0 | 23.5 | 26.5 | 28.0 | 23.25 |
| 2 | 31.0 | 31.5 | 31.5 | 31.0 | 23.0 | 29.25 | 2 | 31 | 18.5 | 21.0 | 21.0 | 21.0 | 20.35 |
| 3 | 30.5 | 6.5 | 9.0 | 11.0 | 10.5 | 9.25 | 3 | 31 | 7.0 | 9.0 | 7.0 | 6.0 | 7.20 |
| 4 | 31.0 | 11.5 | 12.5 | 12.5 | 10.5 | 11.70 | 4 | 31 | — 9.8 | 5.0 | 3.5 | 3.5 | 0.50 |
| 5 | 30.0 | 23.5 | 26.0 | 25.0 | 24.0 | 24.65 | 5 | 30 | 16.0 | 24.5 | 28.0 | 26.0 | 23.60 |
| 6 | 30.0 | 15 5 | 16.5 | 15.0 | 12.5 | 14.80 | 6 | 30 | 26.0 | 29.0 | 29.0 | 27.0 | 27.80 |
| 7 | 30.0 | 8.0 | 11.0 | 11.0 | 10.0 | 10.00 | 7 | 30 | — 3.0 | — 4.0 | — 3.0 | — 8.0 | — 4.50 |
| 8 | 30.0 | 9.0 | 13.5 | 13.5 | 12.0 | 12.00 | 8 | 29 | —28.5 | —21.5 | —17.0 | —15.5 | —20.60 |
| 9 | 31.0 | 3.0 | 4.5 | 4 0 | 5.5 | 4.25 | 9 | 30 | —14.5 | — 2.5 | 4.0 | — 2.0 | — 3.80 |
| 10 | 30.0 | 12.5 | 16.0 | 20.5 | 16.5 | 16.40 | 10 | 30 | 15.5 | 20.5 | 26.5 | 29.5 | 23.00 |
| 11 | 30.0 | —17.5 | —13.5 | —11.0 | —10.5 | —13.80 | 11 | 30 | 29.5 | 40.0 | 39.5 | 40.0 | 37.20 |
| 12 | 31.0 | —18.5 | — 9.0 | — 8.5 | — 9.0 | —11.20 | 12 | 32 | 40.0 | 41.0 | 41.5 | 40.5 | 40.80 |
| 13 | 31.0 | —14.5 | — 6.5 | — 2.0 | — 4.0 | — 6.80 | 13 | 31 | 32.0 | 31.5 | 31.0 | 28.5 | 30.70 |
| 14 | 31.0 | — 6.5 | — 2.5 | 4.0 | 6.0 | 0.25 | 14 | 31 | 20.0 | 26.0 | 29.5 | 28.5 | 25.80 |
| 15 | 31.0 | 13.5 | 18.0 | 21.0 | 22.0 | 18.65 | 15 | 31 | 23.0 | 27.0 | 31.0 | 31.0 | 28.00 |
| 16 | 31.0 | 23.0 | 23.0 | 23.5 | 21.0 | 22.65 | 16 | 31 | 23.5 | 30.0 | 31.5 | 29.5 | 28.60 |
| 17 | 31.0 | 15.5 | 16.0 | 15.5 | 12.0 | 14.80 | 17 | 31 | 30.0 | 30.5 | 31.0 | 31.0 | 30.60 |
| 18 | 31.0 | — 1.0 | 7.0 | 11.0 | 10.0 | 6.80 | 18 | 30 | 30.5 | 31.4 | 31.0 | 29.0 | 30.50 |
| 19 | 30.0 | 15.0 | 16.5 | 18.5 | 15.5 | 16.40 | 19 | 30 | 17.0 | 26.5 | 27.5 | 22.0 | 23.20 |
| 20 | 30.0 | 8.0 | 12.0 | 13.0 | 11.5 | 11.10 | 20 | 30 | 19.5 | 27.5 | 31.5 | 32.5 | 27.80 |
| 21 | 30.0 | 9.5 | 12.0 | 14.0 | 14.0 | 12.40 | 21 | 30 | 27.0 | 30.0 | 23.5 | 20.0 | 25.20 |
| 22 | 30.0 | 7.5 | 10.5 | 13.0 | 10.5 | 10.40 | 22 | 30 | 4.5 | 8.5 | 11.5 | 9.0 | 8.40 |
| 23 | 30.0 | 1.5 | 8.0 | 13.5 | 6.5 | 7.10 | 23 | 30 | 6.5 | 7.5 | 7.5 | 7.5 | 7.20 |
| 24 | 30.0 | — 2.0 | 1.5 | 8.5 | 13.5 | 5.35 | 24 | 30 | 17.0 | 13.5 | 13.5 | 11.0 | 13.80 |
| 25 | 30.0 | 25.5 | 21.0 | 21.0 | 20.5 | 22.00 | 25 | 31 | 14.5 | 26.5 | 31.0 | 28.5 | 25.10 |
| 26 | 31.0 | 22.5 | 25.5 | 27.5 | 24.0 | 23.65 | 26 | 31 | 35.5 | 39.0 | 38.5 | 37.0 | 37.50 |
| 27 | 31.0 | 20.0 | 28.0 | 27.5 | 25.0 | 25.10 | 27 | 31 | 26.5 | 38.5 | 43.5 | 40.5 | 37.25 |
| 28 | 31.0 | 14.5 | 24.5 | 25.5 | 23.5 | 21.30 | 28 | 31 | 34.5 | 40.0 | 43.0 | 41.0 | 39.65 |
| 29 | 31.0 | 24.5 | 28.0 | 28.0 | 27.5 | 27.00 | | | | | | | |
| 30 | 31.0 | 19.0 | 18.5 | 22.0 | 21.0 | 20.10 | | | | | | | |
| 31 | 31.0 | 12.5 | 15.5 | 15.0 | 15.0 | 14.50 | | | | | | | |
| Monthly Means, | 30.57 | 10.02 | 13.5 | 15.2 | 13.7 | 12.90 | Monthly Means, | 30.5 | 17.0 | 22.12 | 23.0 | 22.5 | 21.2 |

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | Thermometer. | | | | Daily Mean. | 1861. | Temp. of | Thermometer. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| March. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | April. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| 1 | 31 | 35.5 | 40.0 | 41.0 | 37.0 | 38.40 | 1 | 31 | 21.5 | 28.0 | 29.0 | 29.5 | 27.00 |
| 2 | 31 | 36.0 | 39.0 | 39.0 | 37.0 | 37.70 | 2 | 31 | 29.5 | 35.5 | 35.0 | 34.0 | 33.50 |
| 3 | 31 | 35.0 | 37.5 | 43.0 | 40.0 | 38.90 | 3 | 31 | 33.0 | 39.0 | 36.0 | 37.0 | 36.20 |
| 4 | 31 | 35.0 | 37.5 | 39.5 | 37.5 | 37.40 | 4 | 31 | 26.5 | 37.0 | 42.5 | 42.0 | 37.00 |
| 5 | 31 | 21.0 | 22.5 | 21.0 | 19.5 | 21.00 | 5 | 31 | 34.5 | 41.0 | 43.5 | 48.0 | 41.80 |
| 6 | 31 | 22.0 | 26.0 | 23.5 | 21.0 | 23.10 | 6 | 32 | 34.5 | 39.5 | 42.0 | 43.5 | 40.10 |
| 7 | 31 | — 7.5 | 1.0 | 6.5 | 6.0 | 1.50 | 7 | 32 | 31.0 | 35.5 | 40.0 | 43.0 | 37.50 |
| 8 | 31 | 13.0 | 21.0 | 26.5 | 24.0 | 20.70 | 8 | 32 | 28.0 | 34.5 | 38.0 | 38.0 | 34.60 |
| 9 | 31 | 38.5 | 37.0 | 34.5 | 34.0 | 36.00 | 9 | 32 | 32.5 | 40.0 | 43.0 | 41.5 | 39.20 |
| 10 | 31 | 31.5 | 30.0 | 26.5 | 24.0 | 28.00 | 10 | 32 | 35.5 | 45.5 | 52.5 | 52.5 | 46.50 |
| 11 | 31 | 12.0 | 16.5 | 19.5 | 19.0 | 16.70 | 11 | 32 | 38.5 | 42.0 | 45.0 | 47.5 | 43.20 |
| 12 | 31 | 24.0 | 23.5 | 25.0 | 21.5 | 23.50 | 12 | 32 | 35.0 | 48.0 | 46.5 | 45.5 | 43.80 |
| 13 | 31 | 14.0 | 17.0 | 21.5 | 22.0 | 18.70 | 13 | 32 | 46.0 | 50.0 | 50.0 | 50.5 | 49.20 |
| 14 | 31 | 5.5 | 13.5 | 17.5 | 13.5 | 12.50 | 14 | 32 | 43.5 | 44.5 | 45.5 | 45.5 | 44.80 |
| 15 | 31 | 17.0 | 25.5 | 29.5 | 24.0 | 22.70 | 15 | 32 | 32.0 | 36.0 | 38.5 | 39.0 | 36.30 |
| 16 | 31 | 14.0 | 27.5 | 31.5 | 31.0 | 26 00 | 16 | 32 | 33.5 | 36.0 | 37.5 | 36.0 | 35.80 |
| 17 | 30 | — 0.5 | 1.5 | 5.5 | 6.0 | 3.00 | 17 | 32 | 30.5 | 31.0 | 31.5 | 30.0 | 30.80 |
| 18 | 30 | — 4.5 | 3.0 | 7.5 | 5.5 | 2.70 | 18 | 33 | 31.5 | 36.5 | 40.0 | 39.5 | 36.80 |
| 19 | 30 | — 4.0 | 5.0 | 12.5 | 11.5 | 6.20 | 19 | 34 | 34.0 | 40.0 | 42.0 | 42.0 | 39.60 |
| 20 | 30 | 7.5 | 18.0 | 23.5 | 20.5 | 16.10 | 20 | 34 | 35.5 | 41.5 | 46.0 | 45.5 | 42.20 |
| 21 | 30 | 15.0 | 22.5 | 26.5 | 25.5 | 23.40 | 21 | 34 | 43.5 | 47.5 | 50.5 | 52.0 | 48.60 |
| 22 | 31 | 29.0 | 32.5 | 36.0 | 35.5 | 33.60 | 22 | 34 | 41.5 | 47.0 | 45.0 | 45.0 | 44.70 |
| 23 | 32 | 27.5 | 32.5 | 38.5 | 38.0 | 34.20 | 23 | 35 | 47.0 | 53.0 | 54.0 | 53.0 | 51.80 |
| 24 | 32 | 34.5 | 35.5 | 35.0 | 30.0 | 33.80 | 24 | 36 | 39.5 | 45.5 | 43.5 | 43.0 | 42.90 |
| 25 | 32 | 27.0 | 33.5 | 34.5 | 33.5 | 32.10 | 25 | 36 | 45.0 | 45.5 | 48.5 | 47.0 | 46.50 |
| 26 | 32 | 37.0 | 37.5 | 35.5 | 35.0 | 36.20 | 26 | 37 | 42.5 | 49.0 | 53.5 | 53.5 | 49.70 |
| 27 | 32 | 34.5 | 35.5 | 35.5 | 36.5 | 35.50 | 27 | 38 | 42.0 | 53.5 | 45.0 | 43 5 | 46.00 |
| 28 | 32 | 24.5 | 30.0 | 32.5 | 33.0 | 30.00 | 28 | 40 | 52.0 | 54.0 | 50.0 | 49.0 | 51.20 |
| 29 | 32 | 30.5 | 35.0 | 39.0 | 32.0 | 35.20 | 29 | 42 | 46.5 | 50.0 | 56.5 | 59.0 | 53.00 |
| 30 | 32 | 42.0 | 40.5 | 36.0 | 33.5 | 38.00 | 30 | 42 | 46.0 | 47.5 | 46.5 | 46.0 | 46.50 |
| 31 | 32 | 17.5 | 22.5 | 27.0 | 28.0 | 23.70 | | | | | | | |
| Monthly Means, | 31 2 | 21.0 | 25.8 | 28.2 | 26.3 | 25.40 | Monthly Means, | 33.8 | 37.0 | 42.5 | 43.9 | 44.0 | 41.7 |

Daily Means of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | Thermometer. | | | | Daily Mean. | 1861. | Temp. of | Thermometer. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | June. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| 1 | 42 | 37.5 | 40.0 | 43.0 | 41.0 | 40.40 | 1 | 56 | 65.0 | 73.0 | 73.5 | 74.0 | 71.40 |
| 2 | 42 | 29.0 | 36.5 | 40.5 | 41.5 | 36.80 | 2 | 55 | 57.0 | 65.0 | 73.5 | 73.0 | 67.20 |
| 3 | 42 | 35.0 | 42.0 | 45.5 | 45.0 | 41.90 | 3 | 56 | 60.0 | 66.0 | 70.5 | 63.5 | 65.00 |
| 4 | 42 | 43.5 | 51.0 | 55.5 | 56.5 | 51.60 | 4 | 56 | 52.0 | 58.5 | 62.5 | 64.0 | 59.20 |
| 5 | 42 | 50.5 | 60.0 | 62.5 | 61.0 | 58.50 | 5 | 56 | 59.5 | 66.5 | 68.5 | 67.5 | 65.50 |
| 6 | 42 | 52.0 | 51.0 | 52.5 | 50.0 | 51.40 | 6 | 56 | 61.0 | 63.0 | 63.5 | 60.5 | 62.00 |
| 7 | 43 | 52.5 | 53.0 | 56.0 | 55.0 | 54.10 | 7 | 58 | 60.5 | 65.5 | 70.0 | 68.5 | 66.10 |
| 8 | 44 | 51.5 | 54.0 | 54.0 | 52.0 | 52.80 | 8 | 58 | 68.0 | 72.5 | 79.0 | 80.5 | 75.00 |
| 9 | 46 | 48.5 | 55.0 | 57.0 | 56.0 | 54.20 | 9 | 60 | 64.5 | 76.0 | 84.5 | 87.5 | 78.30 |
| 10 | 47 | 52.5 | 59.0 | 63.0 | 60.0 | 58.60 | 10 | 63 | 76.0 | 87.0 | 91.0 | 87.5 | 85.40 |
| 11 | 48 | 53.5 | 64.0 | 66.0 | 61.5 | 61.30 | 11 | 65 | 75.5 | 85.0 | 90.5 | 88.0 | 84.70 |
| 12 | 49 | 50.0 | 56.5 | 60.5 | 63.5 | 57.60 | 12 | 66 | 69.0 | 78.0 | 78.5 | 72.5 | 74.50 |
| 13 | 50 | 51.0 | 58.5 | 67.0 | 57.0 | 58.30 | 13 | 64 | 56.5 | 60.0 | 63.5 | 63.0 | 60.70 |
| 14 | 49 | 52.0 | 53.5 | 58.0 | 59.0 | 55.60 | 14 | 60 | 62.0 | 69.5 | 65.5 | 60.0 | 64.20 |
| 15 | 50 | 50.5 | 54.5 | 60.0 | 62.0 | 56.80 | 15 | 60 | 56.0 | 55.5 | 61.0 | 62.5 | 58.80 |
| 16 | 50 | 52.0 | 54.0 | 56.0 | 53.5 | 54.00 | 16 | 62 | 61.0 | 65.0 | 67.0 | 67.0 | 65.00 |
| 17 | 50 | 43.5 | 48.5 | 52.0 | 52.5 | 49.10 | 17 | 60 | 56.5 | 63.0 | 67.5 | 69.0 | 63.90 |
| 18 | 50 | 46.0 | 48.0 | 53.0 | 52.5 | 49.80 | 18 | 62 | 64.5 | 71.0 | 71.0 | 71.5 | 69.50 |
| 19 | 50 | 52.0 | 59.0 | 61.5 | 59.0 | 57.90 | 19 | 63 | 65.0 | 73.5 | 75.5 | 73.5 | 71.80 |
| 20 | 51 | 57.5 | 59.5 | 59.0 | 59.0 | 58.70 | 20 | 63 | 61.5 | 66.0 | 68.0 | 68.5 | 66.00 |
| 21 | 52 | 55.0 | 60.5 | 61.0 | 60.5 | 59.20 | 21 | 62 | 63.0 | 64.5 | 63.0 | 61.0 | 62 80 |
| 22 | 52 | 53.5 | 62.0 | 65.5 | 65.0 | 61.50 | 22 | 62 | 59.5 | 69.5 | 75.0 | 67.5 | 67.70 |
| 23 | 52 | 61.0 | 69.0 | 72.5 | 69.0 | 67.80 | 23 | 64 | 66.0 | 69.5 | 70.5 | 64.5 | 67.60 |
| 24 | 52 | 63.0 | 67.0 | 66.0 | 60.5 | 64.10 | 24 | 63 | 55.5 | 63.0 | 67.0 | 68.5 | 63.50 |
| 25 | 53 | 55.0 | 67.5 | 66.5 | 66.5 | 63.80 | 25 | 64 | 64.0 | 72.0 | 76.0 | 78.5 | 72.60 |
| 26 | 54 | 61.0 | 67.5 | 70.5 | 69.5 | 67.10 | 26 | 65 | 69.5 | 73.5 | 75.0 | 74.0 | 73.00 |
| 27 | 54 | 56.0 | 56.5 | 59.5 | 56.0 | 57.00 | 27 | 66 | 66.5 | 71.5 | 74.5 | 72.5 | 71.20 |
| 28 | 53 | 46.0 | 55.0 | 53.5 | 48.0 | 50.70 | 28 | 66 | 66.5 | 70.5 | 63.5 | 68.5 | 67.20 |
| 29 | 52 | 47.5 | 55.0 | 54.5 | 55.5 | 53.10 | 29 | 66 | 64.5 | 73.0 | 75.0 | 73.0 | 71.30 |
| 30 | 53 | 49.0 | 61.0 | 66.5 | 66.0 | 60.60 | 30 | 66 | 66.0 | 76.0 | 77.0 | 69.0 | 72.00 |
| 31 | 56 | 61.0 | 71.0 | 73.5 | 70.0 | 68.80 | | | | | | | |
| Monthly Means, | 48.8 | 50.6 | 56.4 | 59.1 | 57.5 | 55.90 | Monthly Means, | 61.60 | 63.0 | 69.4 | 72.0 | 70.6 | 68.77 |

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | Thermometer. | | | | Daily Mean. | 1861. | Temp. of | Thermometer. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | August. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| 1 | 63 | 58.5 | 66.0 | 67.5 | 65.5 | 64.30 | 1 | 69 | 69.5 | 74.0 | 78.5 | 77.0 | 74.80 |
| 2 | 64 | 55.0 | 57.5 | 58.5 | 56.5 | 56.80 | 2 | 71 | 74.0 | 81.0 | 82.0 | 81.0 | 78.20 |
| 3 | 60 | 60.0 | 65.0 | 71.0 | 73.0 | 67.20 | 3 | 70 | 75.5 | 79.5 | 81.0 | 78.5 | 78.70 |
| 4 | 64 | 68.0 | 77.0 | 80.5 | 79.5 | 76.20 | 4 | 70 | 75.0 | 81.0 | 80.0 | 76.0 | 78.00 |
| 5 | 61 | 72.5 | 82.0 | 86.5 | 86.5 | 81.80 | 5 | 75 | 72.0 | 78.0 | 80.5 | 71.0 | 75.40 |
| 6 | 63 | 76.5 | 85.0 | 87.5 | 85.0 | 83.50 | 6 | 68 | 66.0 | 68.5 | 68.5 | 68.0 | 67.80 |
| 7 | 63 | 76.0 | 85.0 | 88.0 | 82.5 | 82.80 | 7 | 69 | 64.0 | 70.5 | 74.0 | 73.5 | 71.50 |
| 8 | 64 | 78.5 | 85.5 | 90.0 | 81.5 | 83.90 | 8 | 70 | 66.0 | 74.5 | 74.5 | 73.0 | 72.00 |
| 9 | 64 | 77.5 | 67.5 | 74.5 | 73.5 | 73.20 | 9 | 73 | 65.0 | 74.0 | 78.0 | 75.5 | 73.20 |
| 10 | 65 | 70.0 | 76.0 | 69.5 | 72.0 | 71.80 | 10 | 69 | 72.5 | 76.5 | 76.0 | 68.5 | 73.30 |
| 11 | 64 | 55.5 | 56.5 | 60.0 | 59.5 | 57.90 | 11 | 70 | 63.0 | 67.5 | 71.0 | 70.0 | 67.80 |
| 12 | 64 | 59.0 | 59.0 | 61.0 | 60.5 | 59.90 | 12 | 70 | 58.5 | 65.0 | 70.5 | 67.5 | 65.30 |
| 13 | 65 | 59.0 | 65.0 | 68.5 | 67.5 | 65.00 | 13 | 62 | 60.5 | 70.0 | 70.5 | 68.0 | 67.40 |
| 14 | 65 | 64.5 | 66.5 | 70.0 | 70.5 | 67.80 | 14 | 63 | 60.0 | 64.5 | 70.5 | 66.0 | 65.20 |
| 15 | 61 | 60.0 | 60.5 | 62.5 | 62.0 | 61.30 | 15 | 69 | 66.0 | 74.5 | 76.5 | 73.0 | 72.50 |
| 16 | 61 | 63.0 | 68.0 | 71.0 | 71.5 | 68.40 | 16 | 69 | 66.0 | 77.5 | 77.5 | 75.5 | 74.20 |
| 17 | 61 | 63.5 | 69.5 | 70.0 | 68.0 | 67.70 | 17 | 70 | 67.5 | 77.5 | 77.0 | 74.0 | 73.40 |
| 18 | 62 | 67.0 | 76.5 | 78.0 | 74.0 | 73.80 | 18 | 71 | 68.5 | 74.5 | 77.0 | 74.0 | 73.10 |
| 19 | 63 | 69.0 | 69.0 | 75.5 | 75.0 | 72.10 | 19 | 70 | 60.0 | 65.5 | 69.5 | 69.0 | 66.00 |
| 20 | 61 | 63.0 | 63.5 | 69.5 | 66.0 | 65.50 | 20 | 70 | 60.0 | 70.0 | 74.5 | 72.0 | 69.10 |
| 21 | 59 | 61.5 | 67.0 | 70.5 | 68.5 | 66.90 | 21 | 64 | 67.5 | 67.5 | 69.5 | 70.5 | 68.70 |
| 22 | 66 | 63.5 | 66.0 | 64.5 | 64.5 | 64.60 | 22 | 68 | 61.5 | 64.0 | 68.0 | 65.0 | 64.60 |
| 23 | 66 | 61.0 | 66.0 | 69.0 | 70.5 | 66.60 | 23 | 69 | 60.0 | 66.0 | 70.0 | 68.5 | 66.10 |
| 24 | 65 | 65.0 | 72.0 | 76.0 | 75.5 | 72.20 | 24 | 70 | 68.5 | 73.0 | 76.5 | 68.5 | 72.90 |
| 25 | 69 | 69.0 | 75.0 | 78.5 | 76.5 | 74.80 | 25 | 70 | 66.5 | 74.0 | 76.5 | 74.0 | 72.80 |
| 26 | 70 | 71.0 | 78.5 | 79.5 | 76.5 | 76.40 | 26 | 70 | 69.0 | 76.0 | 75.0 | 72.0 | 73.00 |
| 27 | 69 | 75.0 | 75.5 | 77.5 | 76.0 | 76.00 | 27 | 70 | 70.5 | 74.5 | 73.0 | 73.0 | 72.80 |
| 28 | 70 | 74.0 | 79.0 | 81.0 | 79.0 | 78.40 | 28 | 70 | 67.5 | 74.5 | 77.5 | 75.5 | 73.80 |
| 29 | 70 | 69.5 | 70.5 | 68.5 | 73.5 | 70.00 | 29 | 70 | 66.0 | 73.0 | 76.0 | 74.5 | 72.40 |
| 30 | 70 | 69.5 | 74.0 | 75.5 | 76.5 | 73.80 | 30 | 69 | 65.0 | 70.0 | 65.5 | 65.5 | 66.50 |
| 31 | 69 | 68.0 | 67.0 | 68.5 | 70.5 | 68.40 | 31 | 62 | 56.0 | 61.5 | 62.0 | 60.5 | 60.00 |
| Monthly Means, | 66.60 | 66.5 | 70.7 | 73.0 | 72.1 | 70.50 | Monthly Means, | 69.0 | 66.1 | 72.1 | 72.6 | 71.2 | 70.90 |

Daily Means of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M., and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | Thermometer. | | | | Daily Mean. | 1861. | Temp. of | Thermometer. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| September. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | October. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| 1 | 63 | 58.0 | 63.5 | 67.5 | 66.5 | 63.90 | 1 | 56 | 44.5 | 51.5 | 56 5 | 49.5 | 50.50 |
| 2 | 64 | 58.0 | 65.0 | 69.0 | 69.0 | 65.20 | 2 | 56 | 57.0 | 64.0 | 66.5 | 62.5 | 62.50 |
| 3 | 65 | 70.5 | 75.0 | 77.0 | 73.5 | 74.00 | 3 | 56 | 62.5 | 64.5 | 63.5 | 59.5 | 62.50 |
| 4 | 66 | 60.0 | 65.0 | 66.0 | 64.5 | 63.90 | 4 | 55 | 49.0 | 51.5 | 50.0 | 49.0 | 49.90 |
| 5 | 66 | 57.5 | 64.5 | 65.5 | 64.5 | 63.00 | 5 | 54 | 41.5 | 44.5 | 45.5 | 46.5 | 44.50 |
| 6 | 66 | 66.0 | 70.5 | 71.0 | 68.5 | 69.00 | 6 | 52 | 54.5 | 58.0 | 59.5 | 58.0 | 57.50 |
| 7 | 66 | 57.0 | 64.0 | 69.0 | 64.0 | 63.50 | 7 | 52 | 51.0 | 53.0 | 53.0 | 51.5 | 52.10 |
| 8 | 66 | 54.5 | 59.5 | 62.0 | 61.0 | 59.30 | 8 | 53 | 49.5 | 50.5 | 52.5 | 51.5 | 51.00 |
| 9 | 62 | 54.0 | 59.5 | 63.0 | 61.5 | 59.50 | 9 | 53 | 50.0 | 58.0 | 61.5 | 57.5 | 56.70 |
| 10 | 62 | 60.0 | 67.0 | 69.5 | 65.0 | 65.40 | 10 | 53 | 51.5 | 57.0 | 62.5 | 59.0 | 57.50 |
| 11 | 62 | 58.0 | 58.0 | 56.5 | 55.5 | 57.00 | 11 | 52 | 49.5 | 51.5 | 52.0 | 52.0 | 51.20 |
| 12 | 61 | 57.0 | 63.0 | 66.0 | 64.5 | 62.60 | 12 | 52 | 51.0 | 52.0 | 56.0 | 53.5 | 54.10 |
| 13 | 61 | 60.5 | 70.0 | 72.5 | 69.0 | 68.00 | 13 | 51 | 46.0 | 51.0 | 49.5 | 47.0 | 48.30 |
| 14 | 61 | 66.5 | 72.5 | 72.0 | 70.0 | 71.70 | 14 | 52 | 44.5 | 52.0 | 55.0 | 53.0 | 50.60 |
| 15 | 60 | 68.0 | 72.5 | 72.0 | 65.0 | 69.30 | 15 | 51 | 49.5 | 54.0 | 55.5 | 51.5 | 52.70 |
| 16 | 62 | 52.5 | 57.5 | 60.5 | 60.0 | 57.60 | 16 | 51 | 42.5 | 53.5 | 58.0 | 51.5 | 51.40 |
| 17 | 63 | 56.5 | 63.5 | 65.0 | 63.0 | 62.00 | 17 | 51 | 57.0 | 59.5 | 62.0 | 59.5 | 59.50 |
| 18 | 64 | 57.0 | 67.5 | 73.5 | 70.0 | 67.00 | 18 | 51 | 53.0 | 53.0 | 50.0 | 49.5 | 52.40 |
| 19 | 64 | 68.0 | 74.0 | 75.0 | 74.0 | 72.80 | 19 | 50 | 44.5 | 49.0 | 54.5 | 59.5 | 51.80 |
| 20 | 62 | 60.0 | 61.0 | 60.0 | 56.5 | 59.40 | 20 | 50 | 45.5 | 50.0 | 47.5 | 43.0 | 46.50 |
| 21 | 60 | 49.5 | 49.0 | 48.0 | 47.0 | 48.20 | 21 | 50 | 38.5 | 43.5 | 45.5 | 43.5 | 42.70 |
| 22 | 56 | 47.0 | 49.0 | 50.5 | 51.5 | 49.50 | 22 | 49 | 39.5 | 53.5 | 54.5 | 53.0 | 50.10 |
| 23 | 54 | 50.5 | 55.0 | 57.0 | 56.5 | 54.70 | 23 | 49 | 53.0 | 55.0 | 50.5 | 44.0 | 50.50 |
| 24 | 60 | 52.5 | 57.0 | 61.0 | 59.0 | 57.30 | 24 | 43 | 35.5 | 36.5 | 37.0 | 35.5 | 36.00 |
| 25 | 60 | 54.0 | 64.0 | 66.5 | 63.0 | 61.80 | 25 | 42 | 36.5 | 43.5 | 45.0 | 45.0 | 42.50 |
| 26 | 61 | 58.0 | 66.0 | 69.0 | 66.0 | 64.80 | 26 | 42 | 45.5 | 51.0 | 50.0 | 49.0 | 49.30 |
| 27 | 54 | 60.5 | 60.5 | 59.5 | 59.0 | 59.90 | 27 | 42 | 39.5 | 42.5 | 44.0 | 41.5 | 41.80 |
| 28 | 54 | 55.0 | 55.5 | 55.5 | 54.0 | 55.00 | 28 | 45 | 33.5 | 38.0 | 42.0 | 38.5 | 37.90 |
| 29 | 53 | 45.0 | 50.0 | 51.0 | 48.5 | 48.60 | 29 | 45 | 40.0 | 46.5 | 52.0 | 47.5 | 46.50 |
| 30 | 56 | 47.0 | 50.0 | 53.0 | 50.0 | 50.00 | 30 | 45 | 42.0 | 45.5 | 49.0 | 47.0 | 45.90 |
| | | | | | | | 31 | 42 | 44.5 | 48.0 | 44.5 | 41.0 | 44.20 |
| Monthly Means, | 61.10 | 57.2 | 62.3 | 64.1 | 60.0 | 61.48 | Monthly Means, | 48.0 | 47.5 | 51.0 | 52.2 | 50.1 | 50.10 |

DAILY MEANS of observed Temperatures at two adjacent stations,—Victoria Bridge and Point St. Charles, Montreal, Canada,—at the hours of 9 A.M., Noon, 3 P.M. and 6 P.M.; and also Temperature of the water of the River St. Lawrence, taken daily, at noon.

| 1861. | Temp. of | Thermometer. | | | | Daily Mean. | 1861. | Temp. of | Thermometer. | | | | Daily Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| November. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | | December. | Water. | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| 1 | 42 | 38.5 | 43.5 | 44.5 | 42.5 | 42.20 | 1 | 33 | 27.5 | 29.0 | 27.5 | 27.5 | 27.8 |
| 2 | 42 | 34.0 | 36.5 | 40.0 | 37.5 | 37.00 | 2 | 32 | 22.5 | 25.0 | 23.0 | 22.0 | 23.10 |
| 3 | 42 | 43.0 | 45.5 | 45.5 | 44.0 | 44.40 | 3 | 32 | 12.5 | 15.5 | 17.5 | 17.0 | 15.7 |
| 4 | 41 | 44.0 | 45.5 | 45.0 | 43.5 | 44.50 | 4 | 32 | 10.0 | 19.0 | 25.0 | 24.0 | 19.6 |
| 5 | 41 | 42.5 | 46.5 | 47.5 | 48.0 | 46.20 | 5 | 32 | 31.0 | 33.0 | 34.0 | 34.0 | 33.0 |
| 6 | 41 | 40.5 | 43.5 | 44.0 | 44.5 | 43.10 | 6 | 32 | 27.0 | 30.5 | 34.0 | 34.0 | 31.5 |
| 7 | 41 | 41.5 | 46.0 | 45.5 | 42.2 | 43.70 | 7 | 32 | 39.5 | 42.5 | 43.0 | 41 0 | 41.5 |
| 8 | 40 | 35.0 | 38.0 | 40.0 | 37.5 | 37.60 | 8 | 32 | 43.0 | 46.5 | 45.5 | 45.0 | 45.0 |
| 9 | 40 | 37.5 | 39.0 | 39.0 | 38.5 | 38.50 | 9 | 32 | 37.0 | 40.0 | 41.5 | 39.0 | 39.3 |
| 10 | 40 | 31.5 | 38.5 | 39.5 | 38.0 | 36.80 | 10 | 32 | 37.5 | 40.0 | 47.5 | 47.5 | 43.1 |
| 11 | 39 | 41.5 | 42.0 | 45.0 | 40.0 | 42.30 | 11 | 32 | 33.0 | 26.5 | 23.5 | 20.0 | 25.8 |
| 12 | 38 | 37.0 | 37.5 | 37.5 | 36.0 | 37.00 | 12 | 32 | 20.5 | 26.0 | 28.5 | 27.0 | 25.5 |
| 13 | 38 | 31.0 | 34.0 | 35.5 | 35.5 | 34.40 | 13 | 32 | 32.0 | 37.0 | 37.5 | 36.5 | 35.7 |
| 14 | 37 | 33.0 | 35.5 | 36.0 | 33.5 | 34.50 | 14 | 32 | 33.5 | 41.5 | 43.0 | 40.5 | 39.4 |
| 15 | 36 | 30.0 | 32.0 | 33.0 | 31.5 | 31.60 | 15 | 32 | 20.5 | 24.0 | 25.0 | 26.0 | 23.9 |
| 16 | 36 | 31.0 | 34.0 | 38.5 | 39.5 | 35.80 | 16 | 32 | 34.0 | 39.5 | 34.5 | 35.5 | 35.9 |
| 17 | 34 | 34.5 | 36.0 | 37.5 | 36.5 | 36.20 | 17 | 32 | 17.5 | 22.5 | 25.0 | 23.0 | 22.4 |
| 18 | 33 | 32.0 | 35.0 | 38.0 | 36.5 | 35.40 | 18 | 32 | 36.5 | 37.0 | 32.5 | 35.0 | 35.4 |
| 19 | 33 | 29.5 | 32.0 | 34.0 | 31.5 | 31.70 | 19 | 32 | 21.0 | 31.0 | 30.0 | 29.0 | 27.7 |
| 20 | 33 | 28.5 | 33.5 | 36.5 | 32.5 | 32.70 | 20 | 32 | 18.5 | 14.0 | 12.5 | 8.0 | 13.2 |
| 21 | 33 | 28.0 | 32.5 | 34.0 | 33.5 | 32.00 | 21 | 32 | —3.5 | 1.0 | 7.0 | 10.0 | 3.6 |
| 22 | 33 | 30.0 | 35.5 | 37.5 | 34.5 | 34.40 | 22 | 32 | 21.5 | 27.0 | 27.5 | 25.5 | 25.3 |
| 23 | 33 | 33.0 | 36.5 | 35.0 | 35.5 | 35.00 | 23 | 32 | 23.0 | 24.5 | 23.5 | 24.0 | 23.8 |
| 24 | 33 | 33.5 | 36.5 | 36.5 | 33.0 | 33.60 | 24 | 32 | 17.5 | 19.0 | 16.0 | 12.0 | 16.2 |
| 25 | 33 | 34.5 | 36.0 | 35.0 | 34.0 | 34.90 | 25 | 32 | —0.0 | 6.5 | 8.5 | 7.5 | 5.6 |
| 26 | 33 | 32.0 | 34.5 | 34.5 | 32.5 | 33.60 | 26 | 32 | 4.5 | 9.5 | 13.0 | 18.0 | 11.4 |
| 27 | 33 | 29.0 | 30.0 | 30.0 | 29.5 | 29.60 | 27 | 33 | 35.5 | 34.0 | 20.0 | 14.0 | 25.9 |
| 28 | 33 | 35.0 | 34.5 | 31.5 | 29.0 | 33.10 | 28 | 31 | 1.0 | 6.5 | 9.5 | 8.0 | 6.2 |
| 29 | 33 | 29.0 | 32.5 | 35.5 | 35.0 | 33.00 | 29 | 31 | 9.0 | 13.0 | 12.5 | 13.0 | 11.9 |
| 30 | 33 | 32.0 | 33.0 | 35.0 | 33.0 | 33.40 | 30 | 31 | 18.0 | 21.0 | 21.0 | 18.0 | 19.5 |
| | | | | | | | 31 | 31 | 16.5 | 20.5 | 24.0 | 23.0 | 21.0 |
| Monthly Means, | 36.60 | 34.4 | 37.1 | 38.2 | 36.6 | 36.60 | Monthly Means, | 31.90 | 22.1 | 25.8 | 26.2 | 24.9 | 24 95 |

## ANALYSIS OF THE FOREGOING OBSERVATIONS.

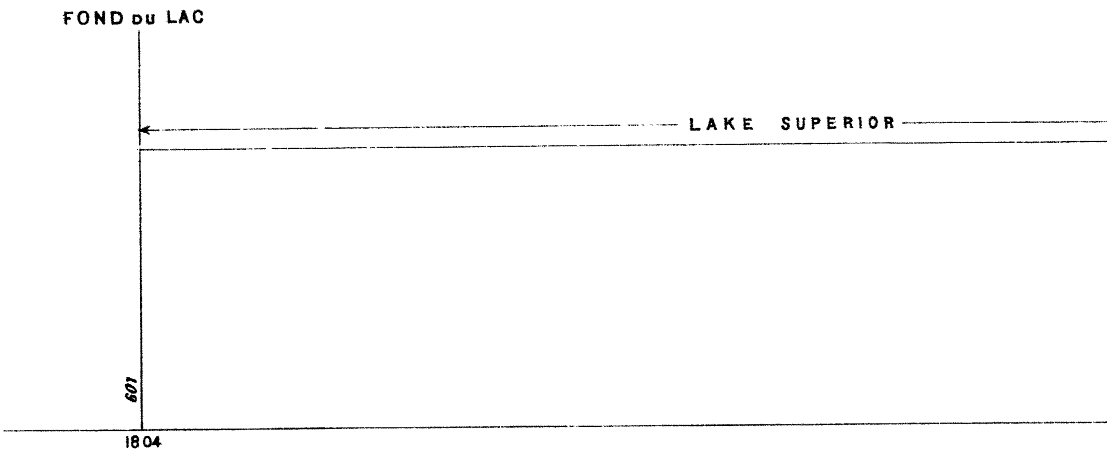
| 1861. | Monthly Mean of Water at Noon. | Monthly Mean Temperature of Air. 9 A.M. | Noon. | 3 P.M. | 6 P.M. | Monthly Mean of Air. |
|---|---|---|---|---|---|---|
| January, . . . . | 30.50 | 10.0 | 13.5 | 15.2 | 13.7 | 12.90 |
| February,. . . . | 30.55 | 17.0 | 22.1 | 23.0 | 22.5 | 21.20 |
| March, . . . . . | 31.20 | 21.0 | 25.8 | 28.2 | 26.3 | 25.40 |
| April,. . . . . . | 33.80 | 37.0 | 42.5 | 43.9 | 44.0 | 41.70 |
| May, . . . . . . | 48.80 | 50.6 | 56.4 | 59.1 | 57.5 | 55.90 |
| June, . . . . . . | 61.60 | 63.0 | 69.4 | 72.0 | 70.6 | 68.77 |
| July, . . . . . . | 66.60 | 66.5 | 70.7 | 73.0 | 72.1 | 70.50 |
| August,. . . . . | 69.00 | 66.1 | 72.1 | 72.6 | 71.2 | 70.90 |
| September, . . . | 61.10 | 57.2 | 62.3 | 64.1 | 60.0 | 61.48 |
| October, . . . . | 48.00 | 47.5 | 51.0 | 52.2 | 50.1 | 50.10 |
| November, . . . | 36.60 | 34.4 | 37.1 | 38.2 | 36.6 | 36.60 |
| December, . . . | 31.90 | 22.1 | 25.8 | 26.2 | 24.9 | 24.95 |
| | | 9 A.M. | Noon. | 3 P.M. | 6 P.M. | |
| Yearly Means, | 45.80 | 40.96 | 45.72 | 47.30 | 45.80 | 45.03 |

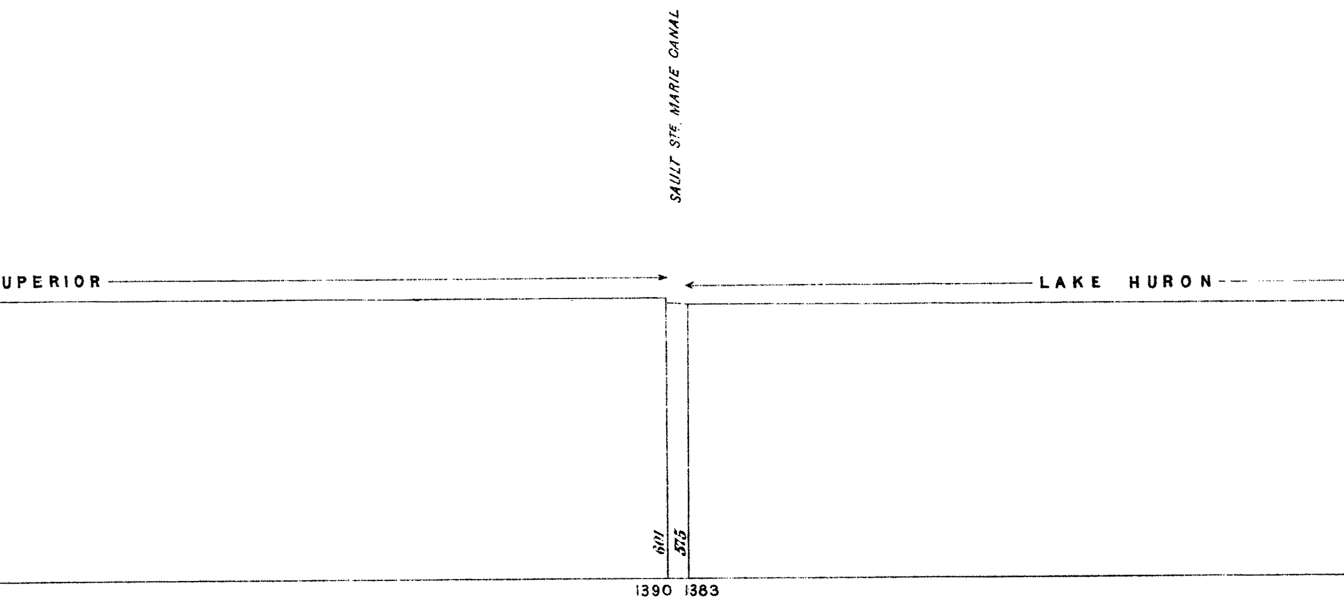
### Mean Temperatures between 9 A.M. and 6 P.M.

| | | | |
|---|---|---|---|
| Mean of Air, Nov., Dec., Jan., Feb., March (151 days), . . . . . . . . . . . . | 24.2 | Number of days At and below zero,. . . | 16 |
| Maximum, . . . . . . . . . . . . . . | + 47.5 | " " " 32°, . . . | 113 |
| Minimum, . . . . . . . . . . . . . . | — 28.5 | " " " 24.2°, . . | 75 |
| Range, . . . . . . . . . . . . . . . | 76° | | |
| April, May, October (92 days), . . . . . . | 49.23 | At and below 32°, . . . | 8 |
| Maximum, . . . . . . . . . . . . . . | 73.5 | " " above 49.23°, . . | 58 |
| Minimum, . . . . . . . . . . . . . . | 21.5 | " " " 60°, . . . | 19 |
| Range, . . . . . . . . . . . . . . . | 52° | " " " 70°, . . . | 3 |
| June, July, August, September (122 days), . | 67.91 | At and below 50°, . . . | 4 |
| Maximum, . . . . . . . . . . . . . . | 91. | " " above 67.91°, . . | 86 |
| Minimum, . . . . . . . . . . . . . . | 45.5 | " " " 80°, . . . | 14 |
| Range, . . . . . . . . . . . . . . . | 45.5° | " " " 90°, . . . | 3 |

Total number of days in the year below 32°, . . 121.
Extreme Range of the year between 9 A.M. and 6 P.M., . . . . . . . . . . . . 119.5
" " in any 24 hours, Summer, July 10 and 11, . . . . . . . . . . 20.5
" " " " " Winter, January 10 and 11, . . . . . . . . 38.0

Extreme Range of Temperature of Water, 46°.
Maximum Temperature, 75°. Minimum Temperature, 29°.
Total number of days at and below 32°, 120.


FOND DU LAC
LAKE SUPERIOR
601
1804


SAULT STE. MARIE CANAL
UPERIOR
LAKE HURON
601
575
1390
1383

SECTION

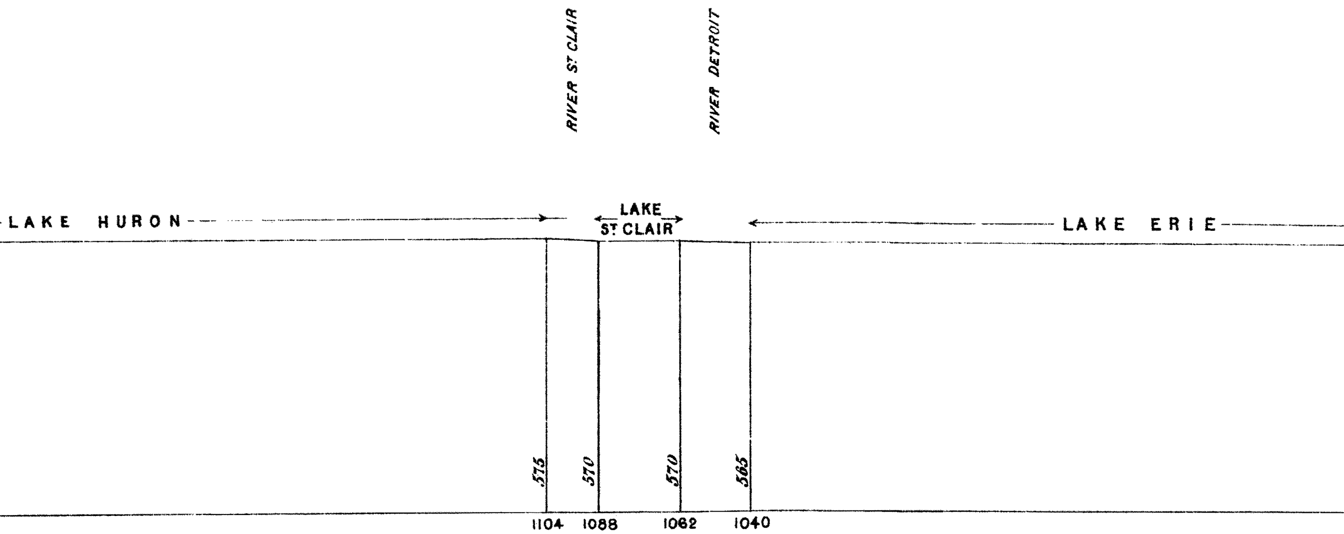
OF

# LAKE RIVER AND CANAL

FROM

LAKE SUPERIOR TO THE GULF OF T

*Horizontal Scale. Sixty miles to one*
*Vertical Scale, Four hundred feet to*




T. SINCLAIR'S LITH. 311 CHEST. ST PHIL.

SECTION

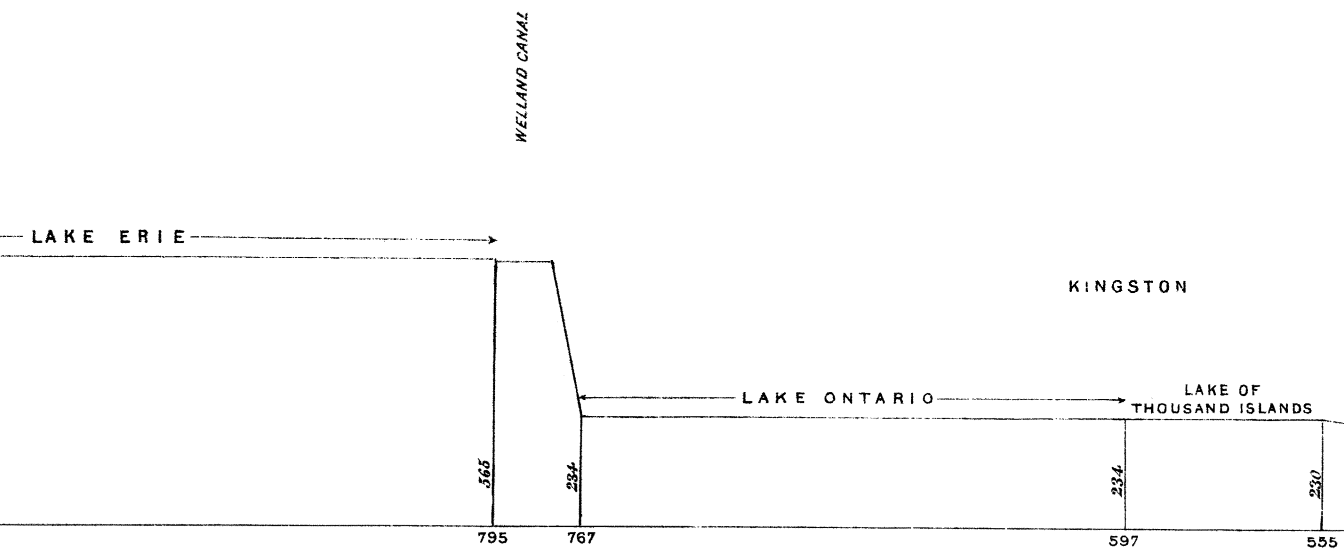
OF

AND CANAL NAVIGATION

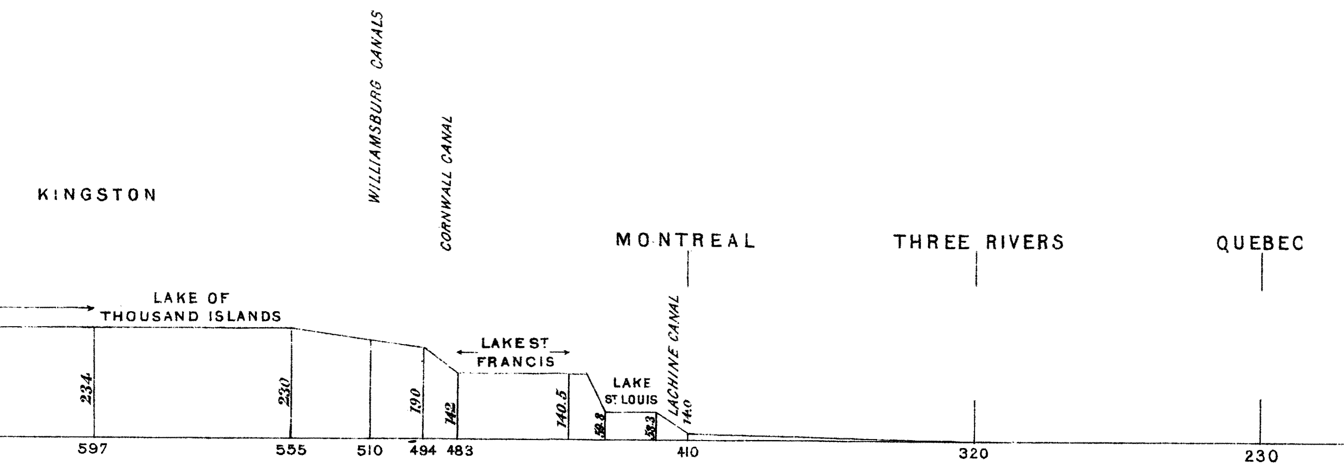
FROM

TO THE GULF OF THE ST LAWRENCE

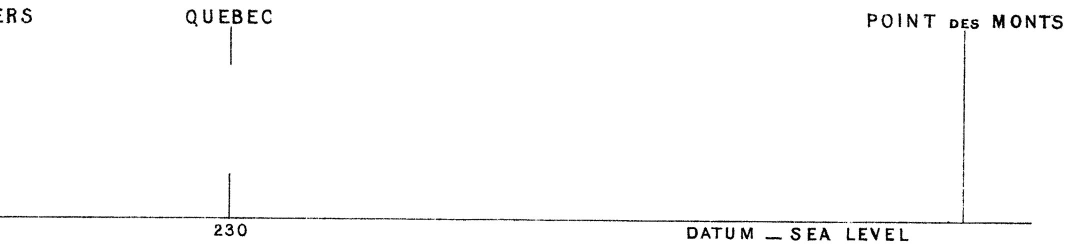
*rizontal Scale. Sixty miles to one inch.*
*rtical Scale, Four hundred feet to one inch.*




T. SINCLAIR'S LITH. 311 CHEST. ST PHIL.



KINGSTON
WILLIAMSBURG CANALS
CORNWALL CANAL
MONTREAL
THREE RIVERS
QUEBEC
LAKE OF THOUSAND ISLANDS
LAKE ST FRANCIS
LAKE ST LOUIS
LACHINE CANAL
234
230
190
142
140.5
14.0
597
555
510
494
483
410
320
230


ERS
QUEBEC
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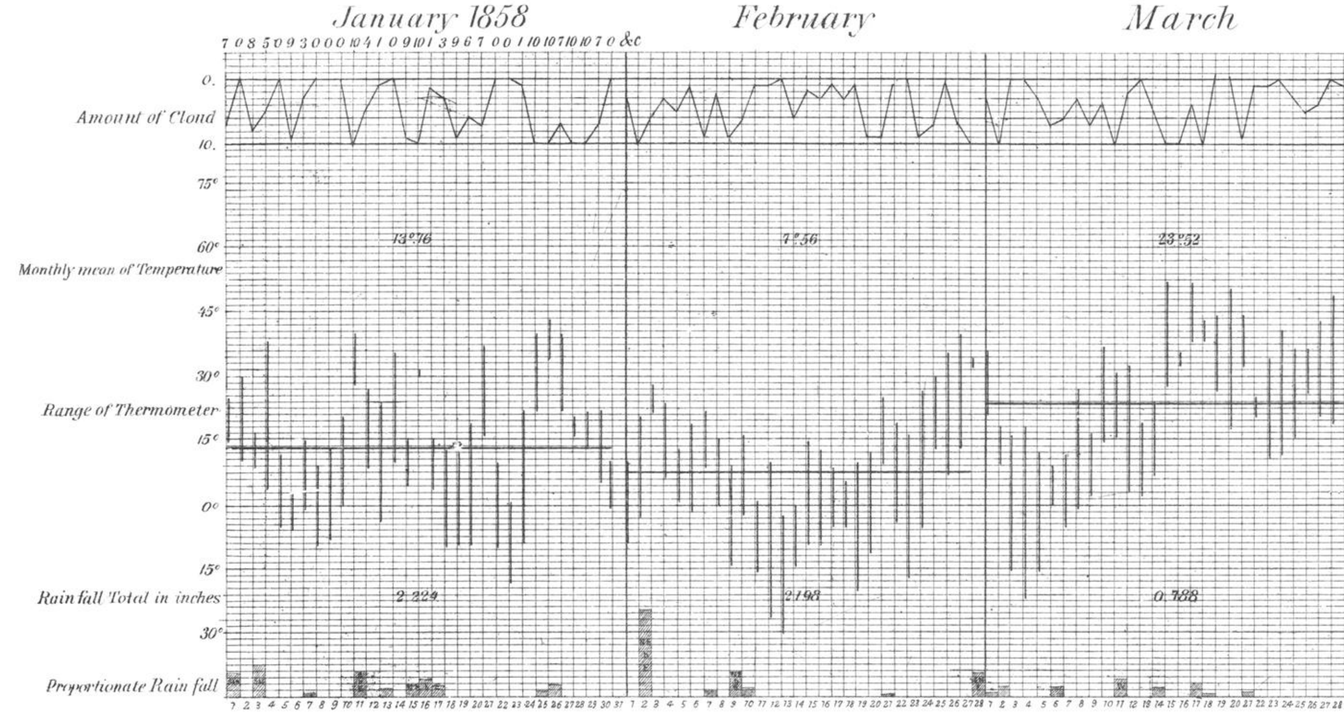
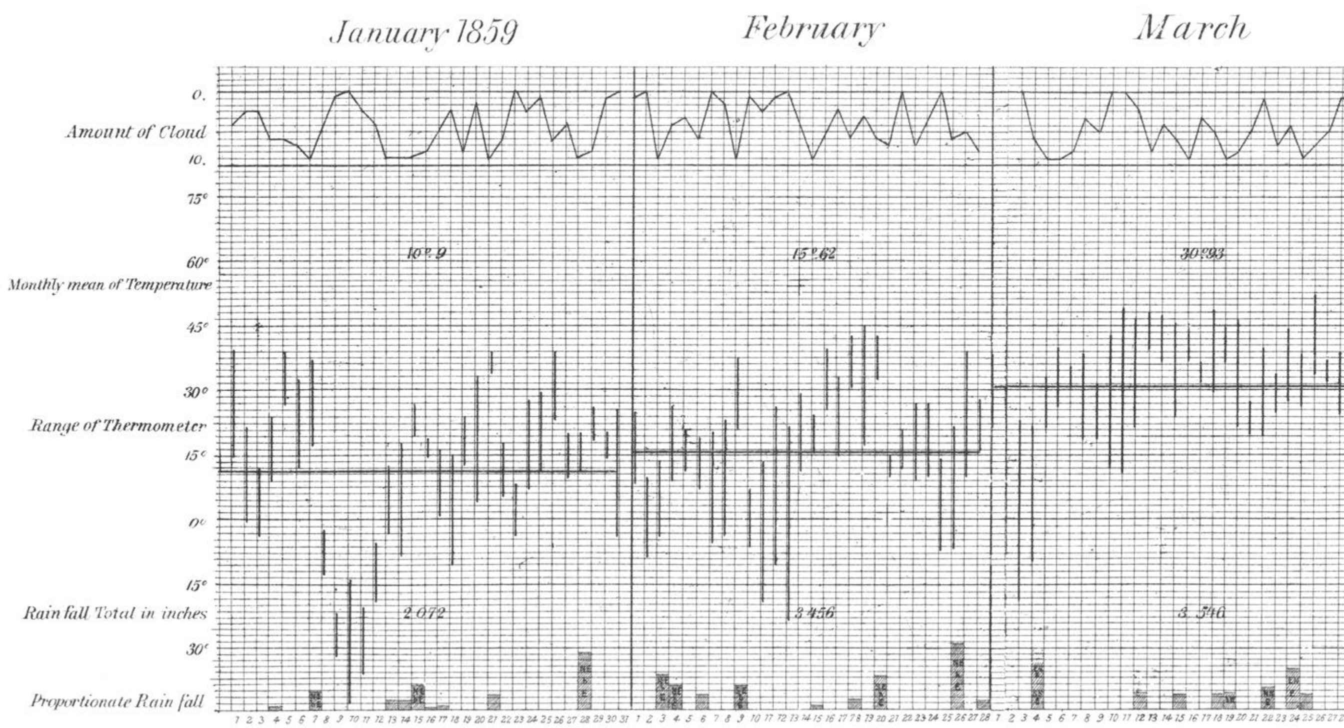
230
DATUM — SEA LEVEL

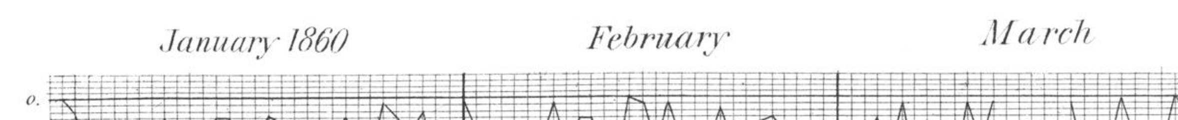
M

T. E. Blackwell.

shewing the daily F

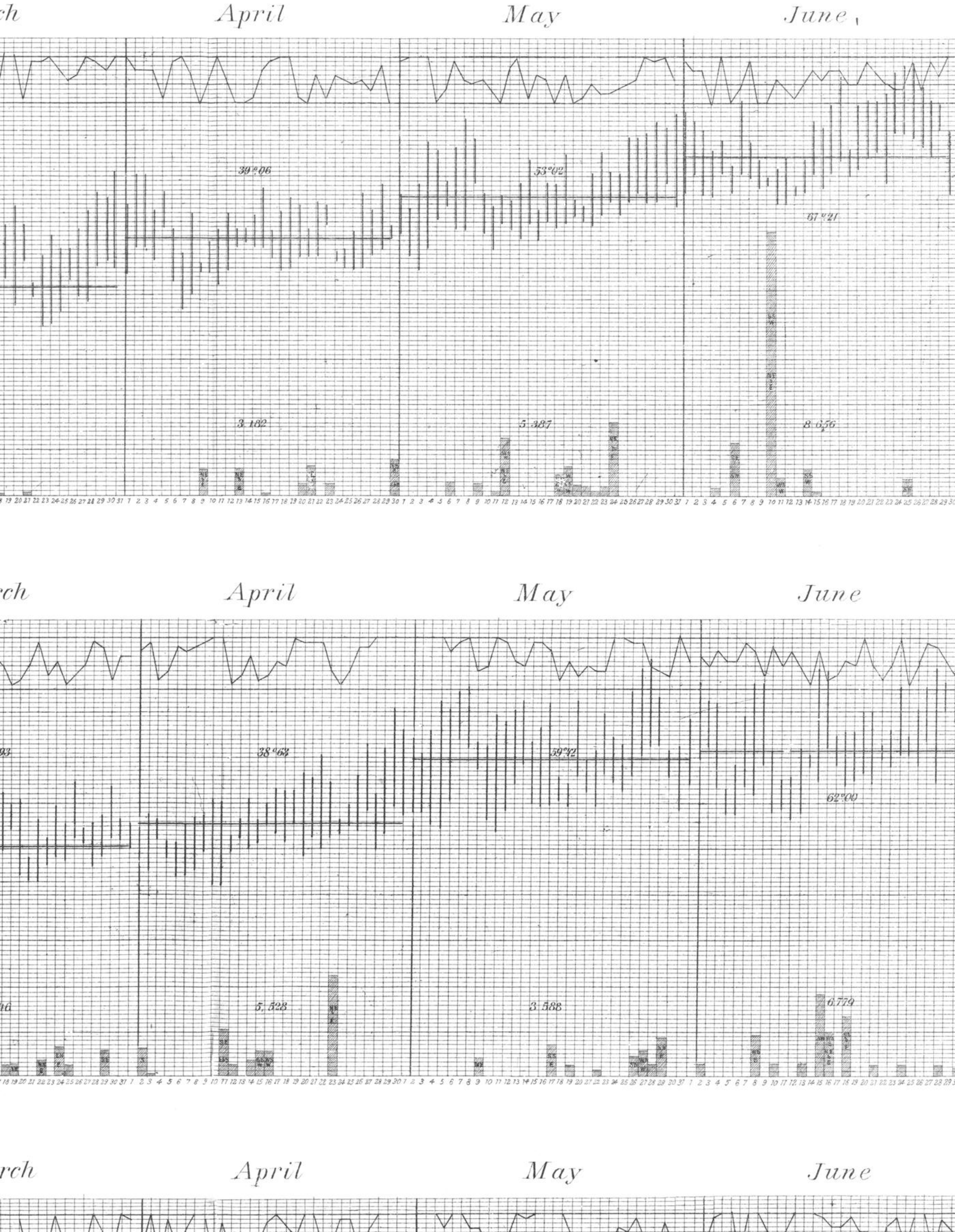


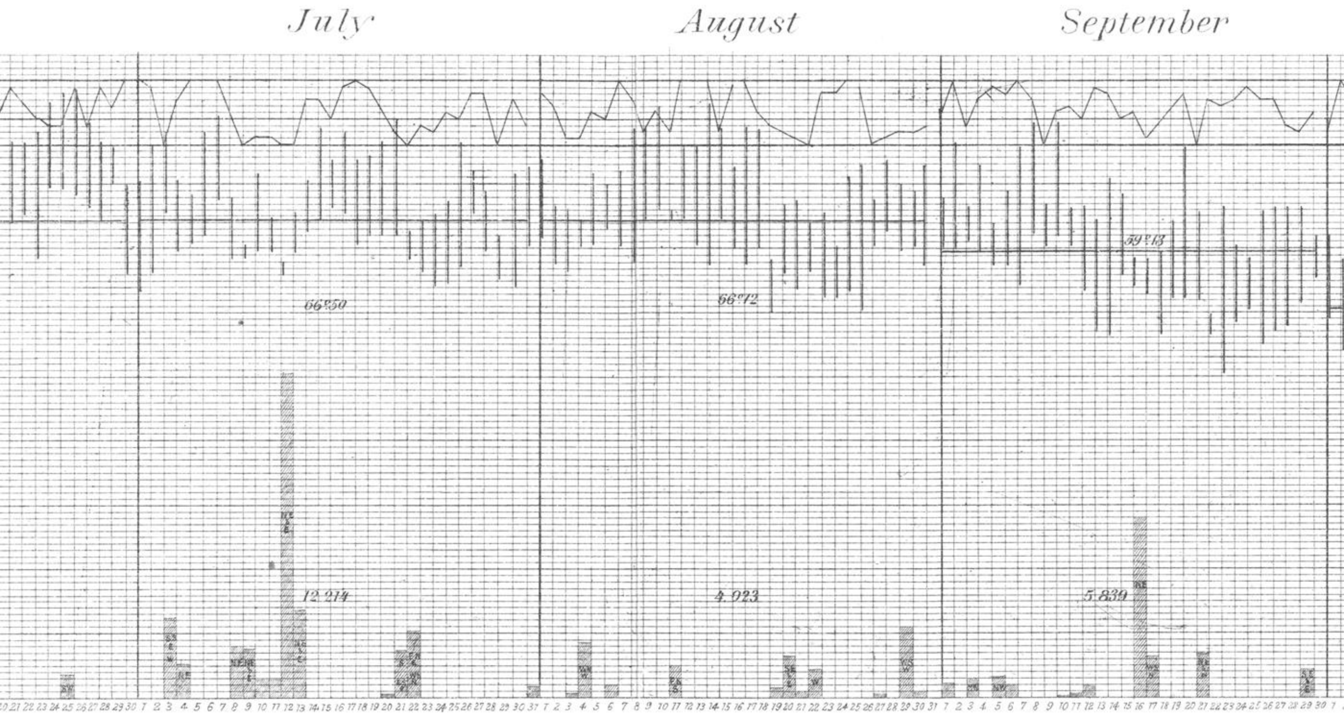
# Meteorological Obse

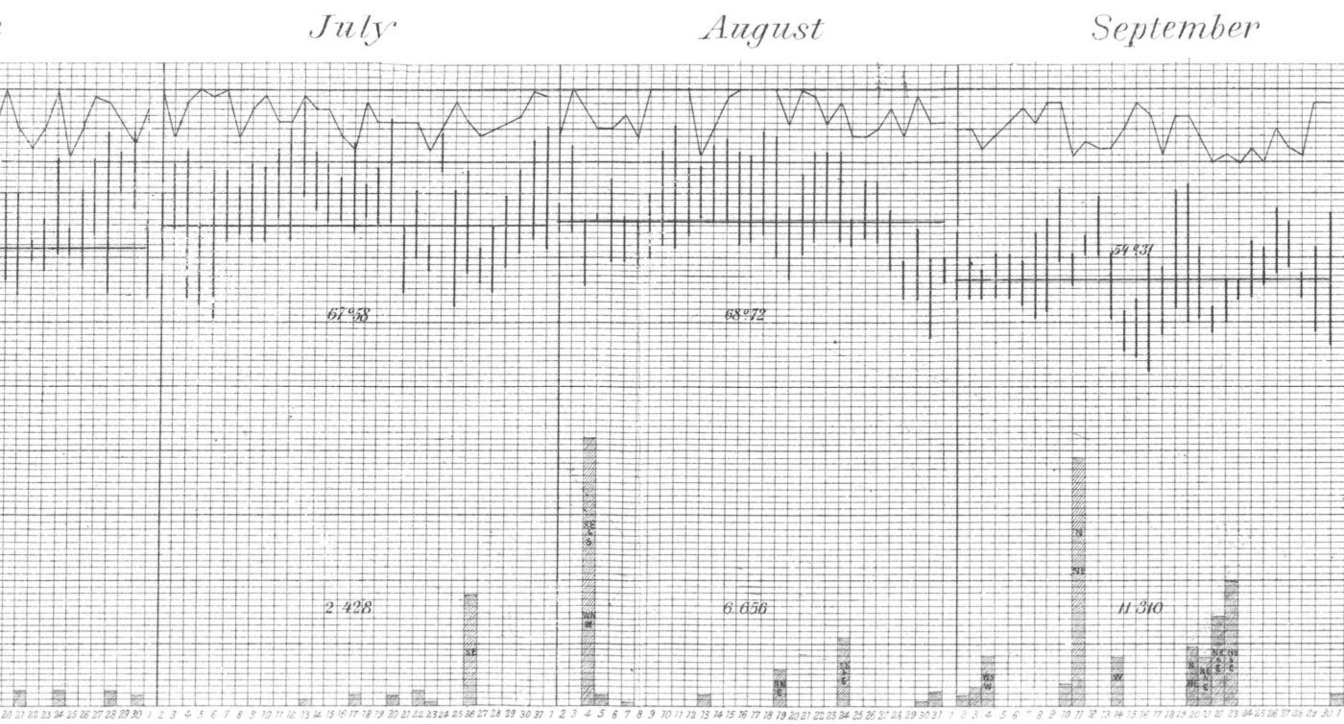
daily Range of temperature the proportion of Cloud and the quantity of

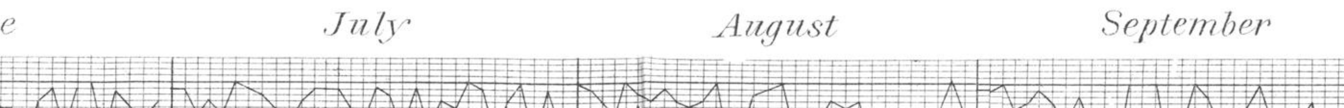


…BSERVATIONS AT MONTRE…

…tity of Rain with the direction of the Rain bearing Winds, during the yea…



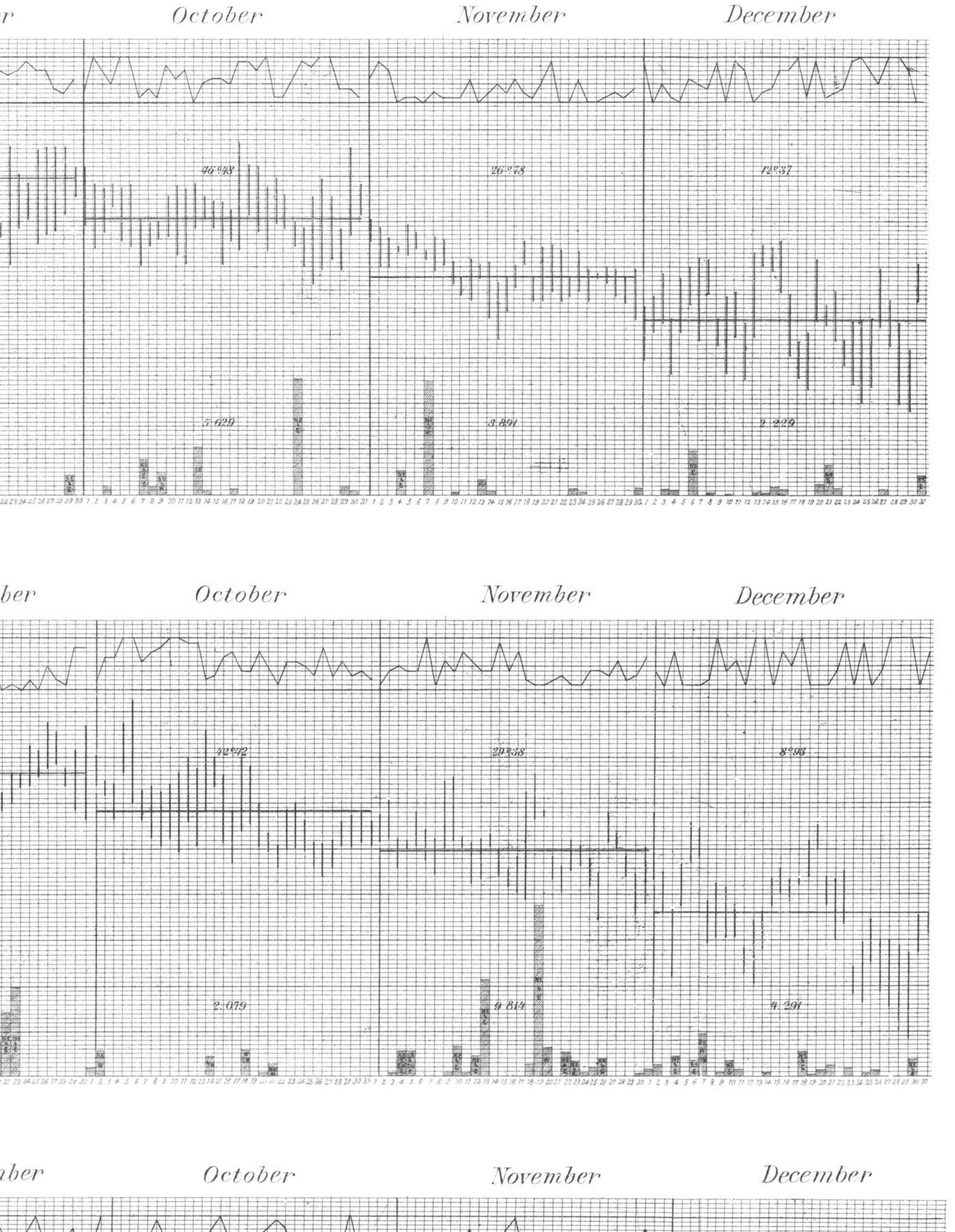



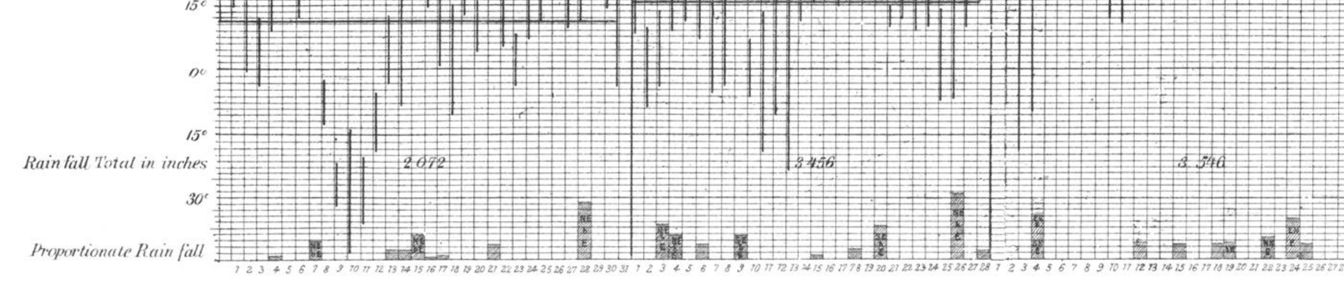



...REAL

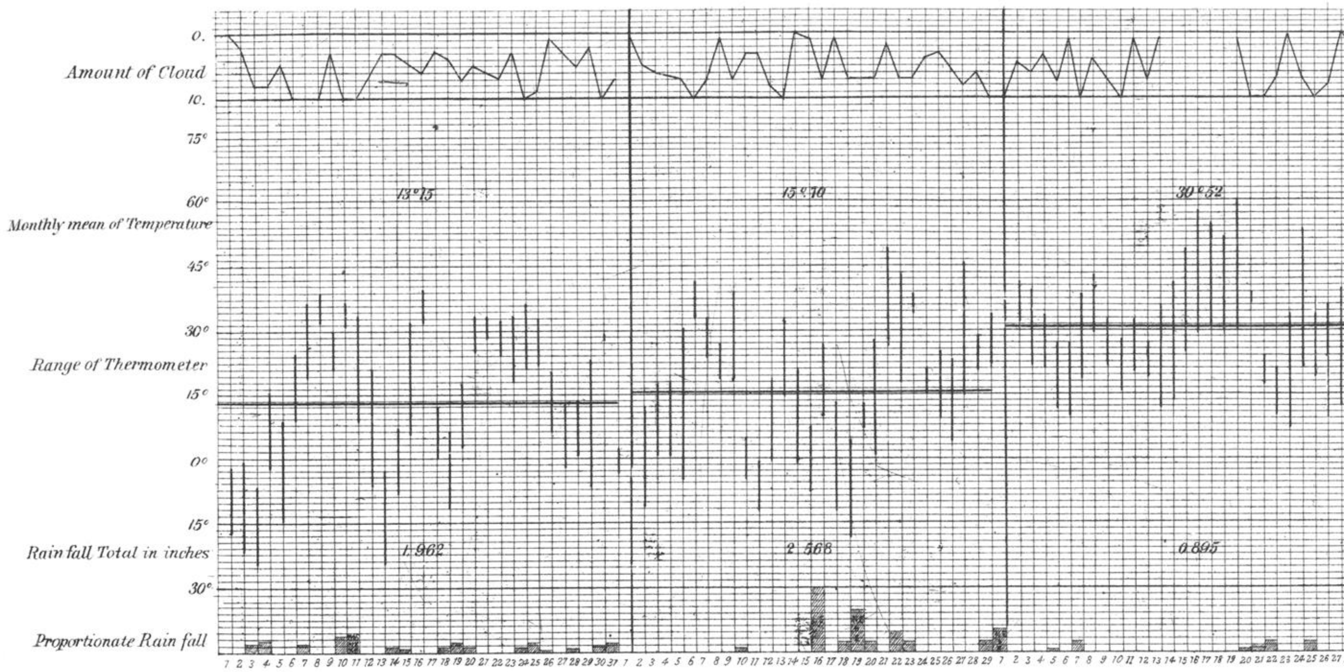
the years 1858, 1859, 1860, 1861.

Trans. Amer. Philosoph. Soc. Vol. XIII. Pl. V.

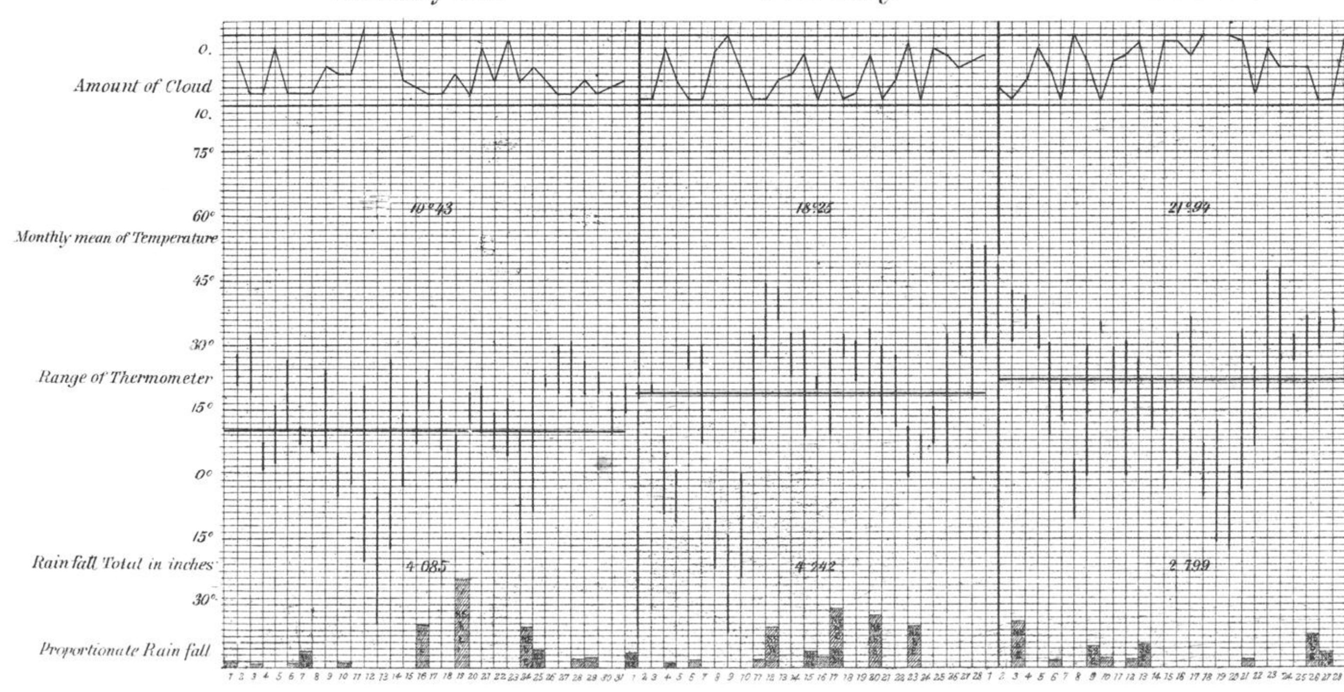


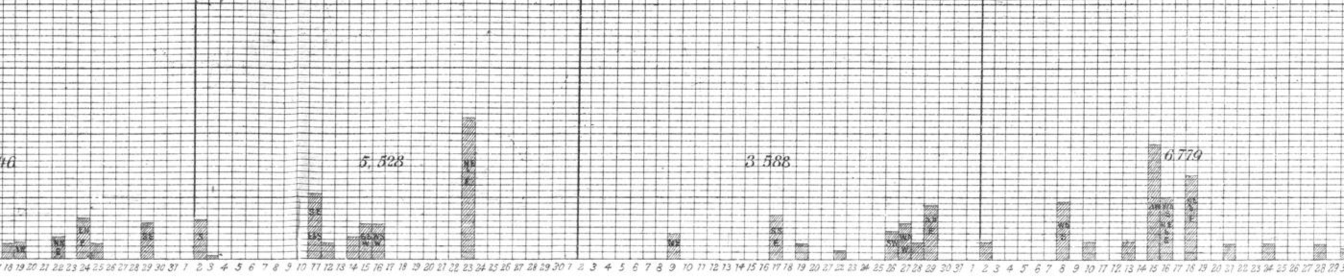


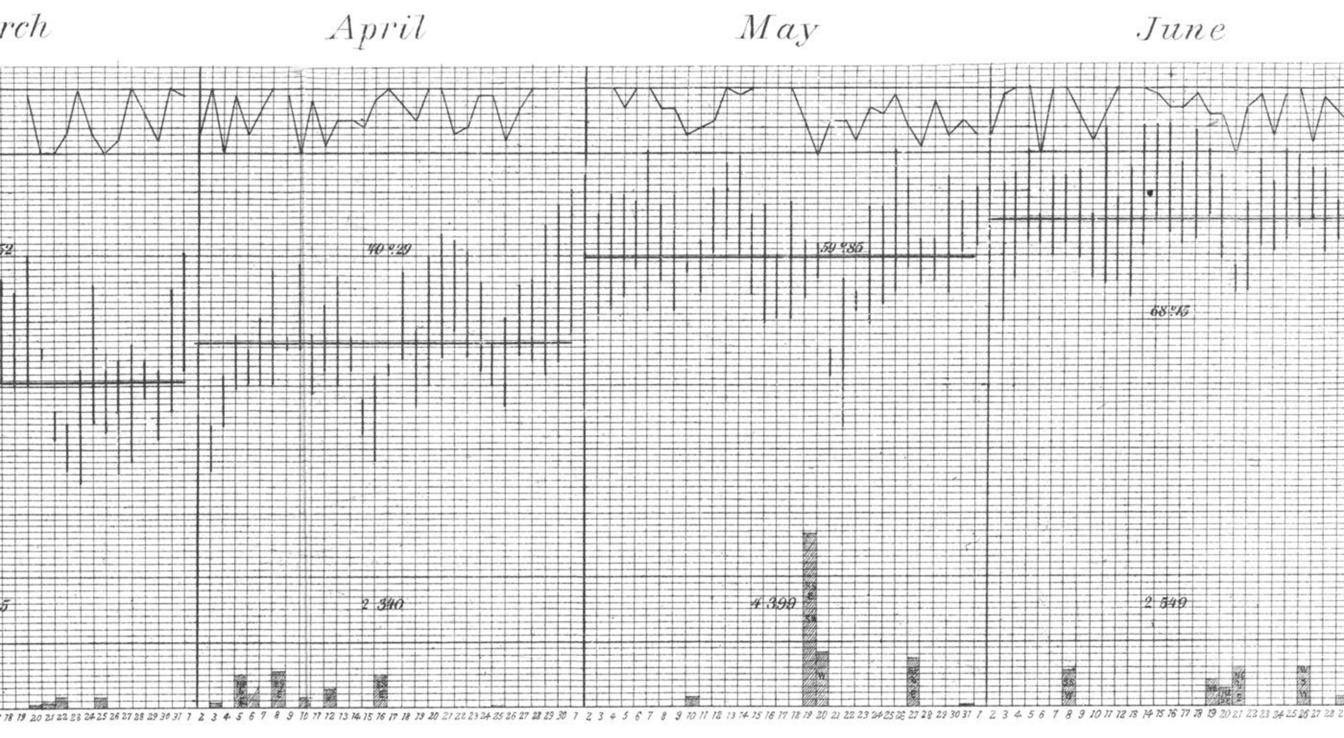

January 1860 February March

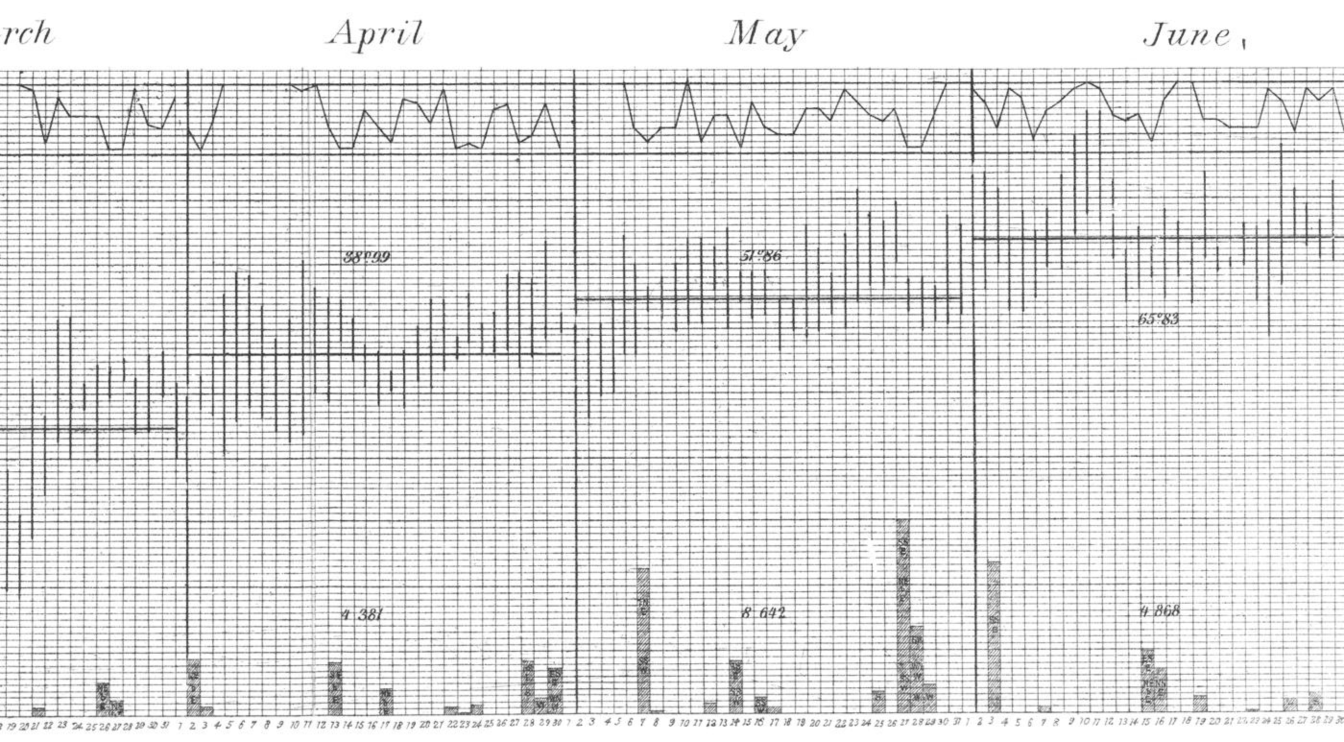


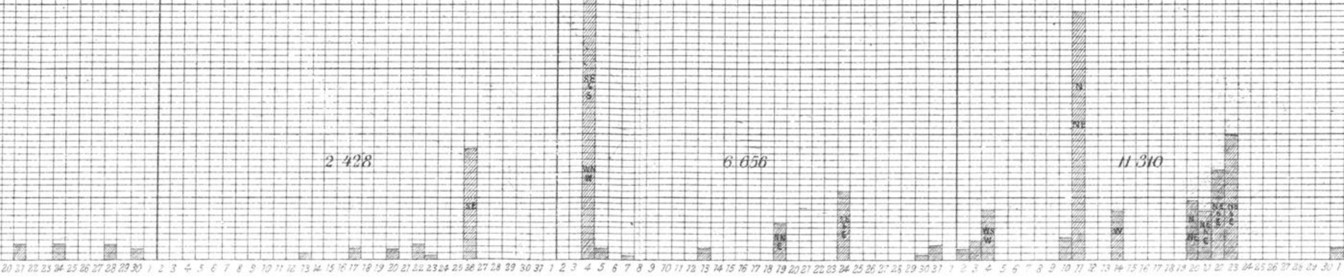

January 1861 February March

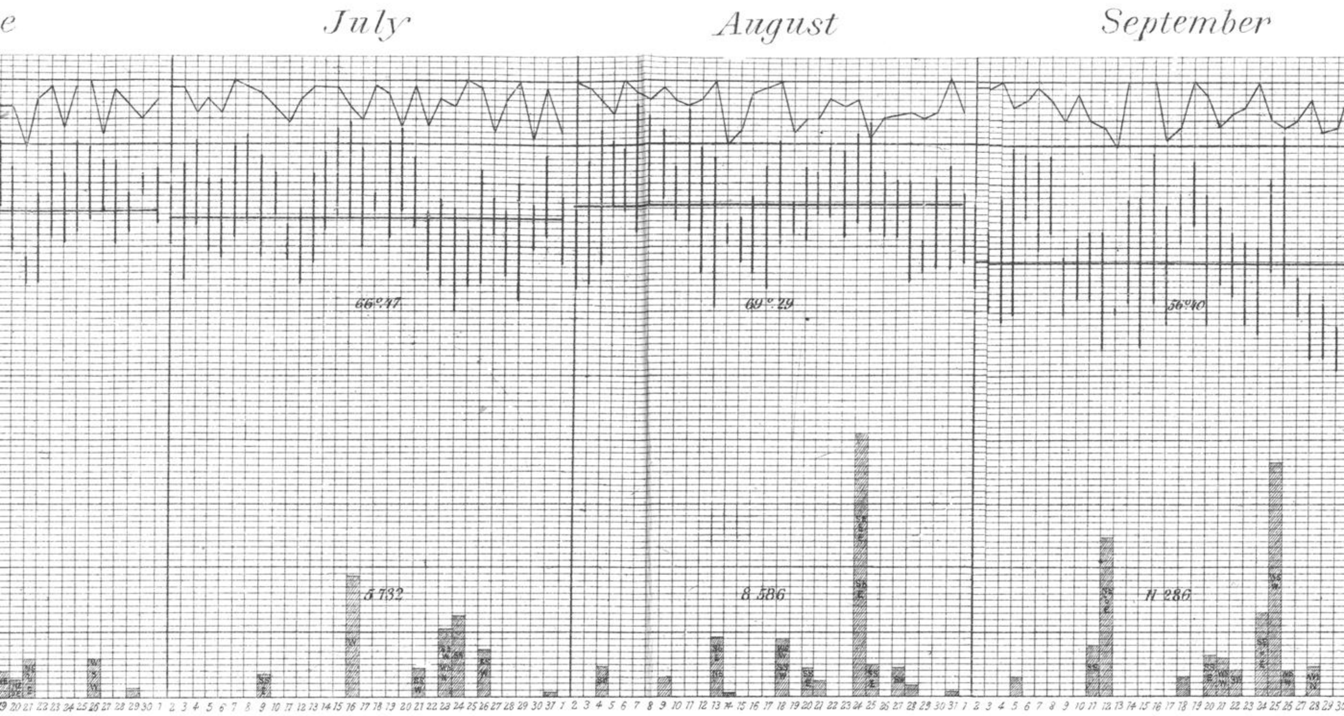


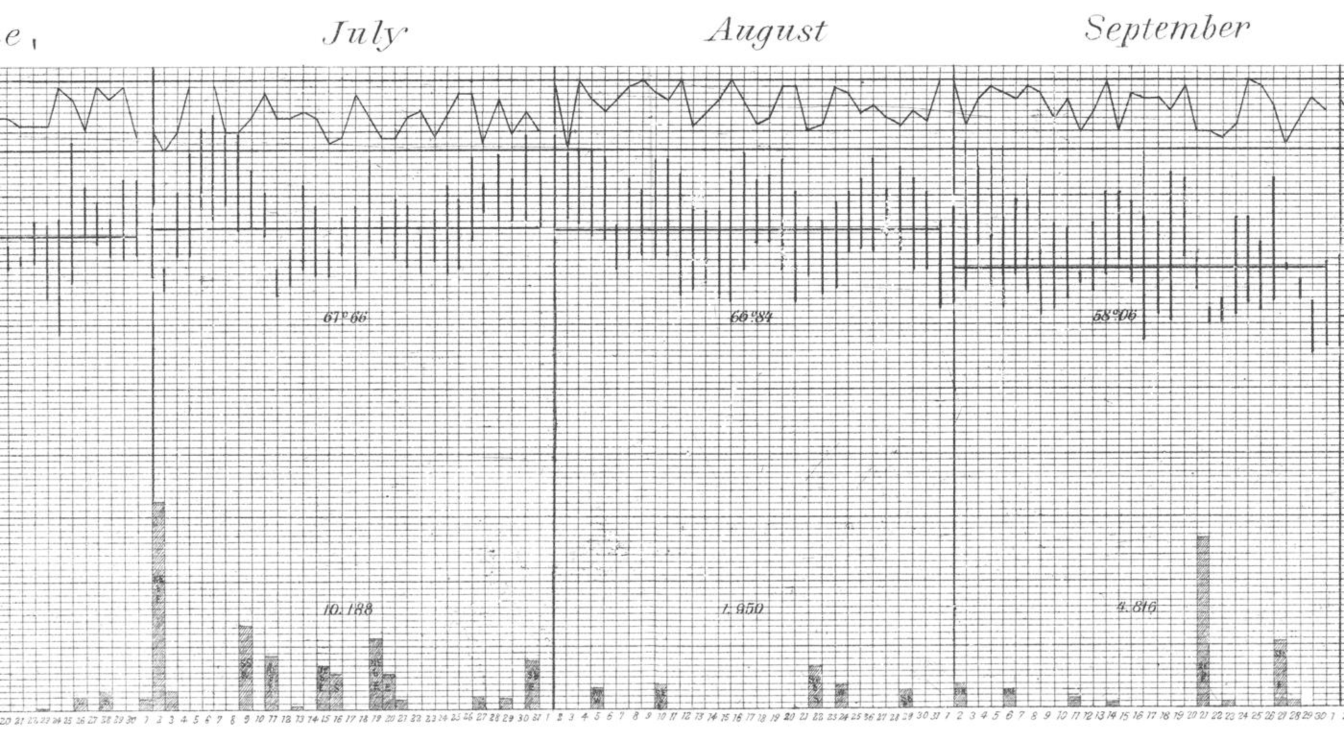

46
5, 528
3 588
6.779

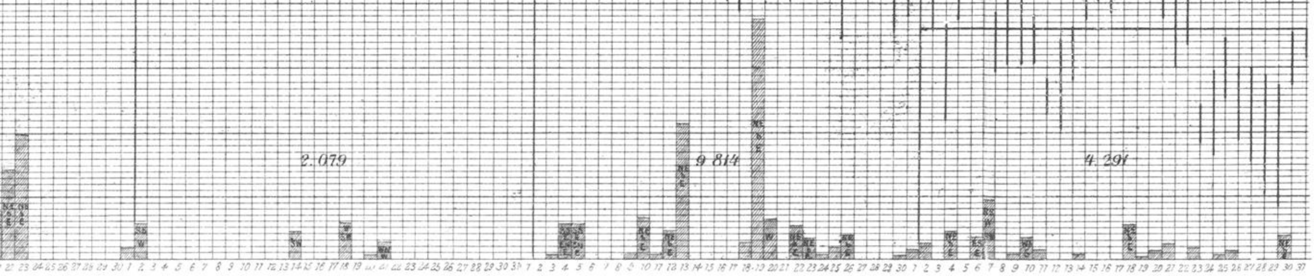

rch
April
May
June
40°29
59°85
68°45
2 340
4 399
2 549

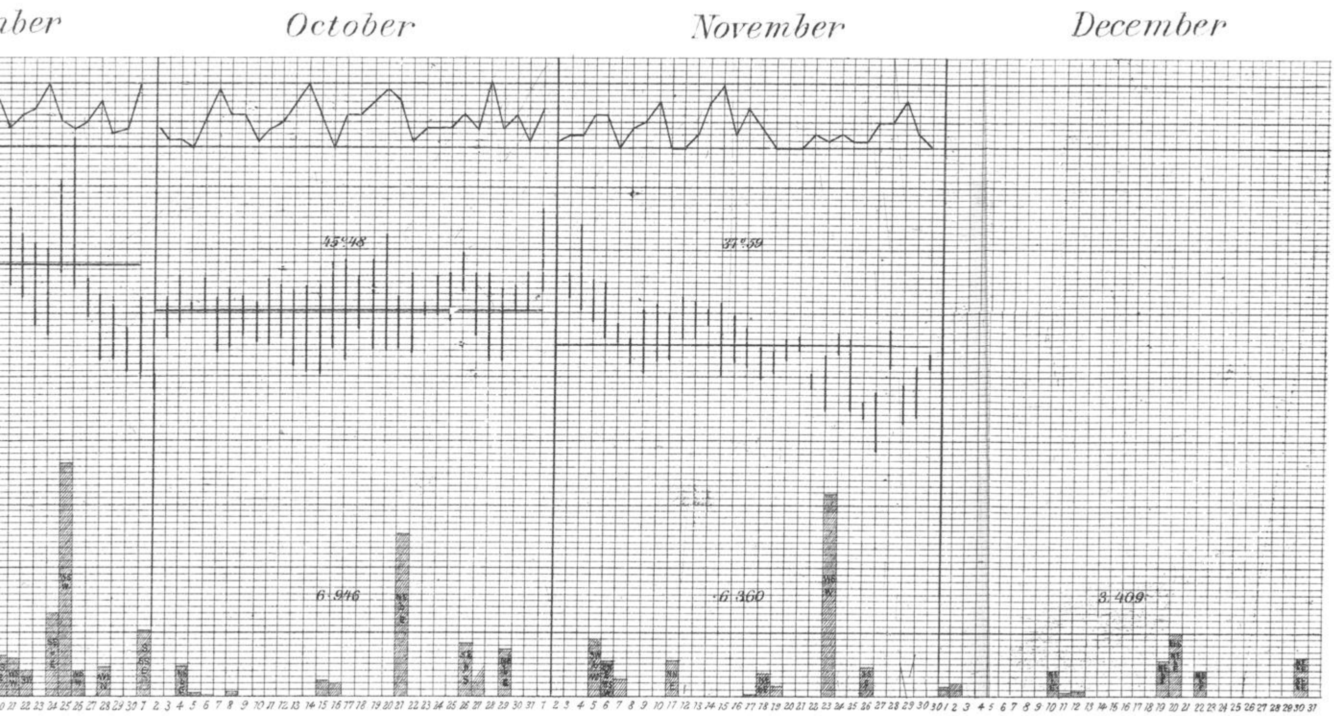

rch
April
May
June
38°99
51°86
65°83
4 381
8 642
4 868

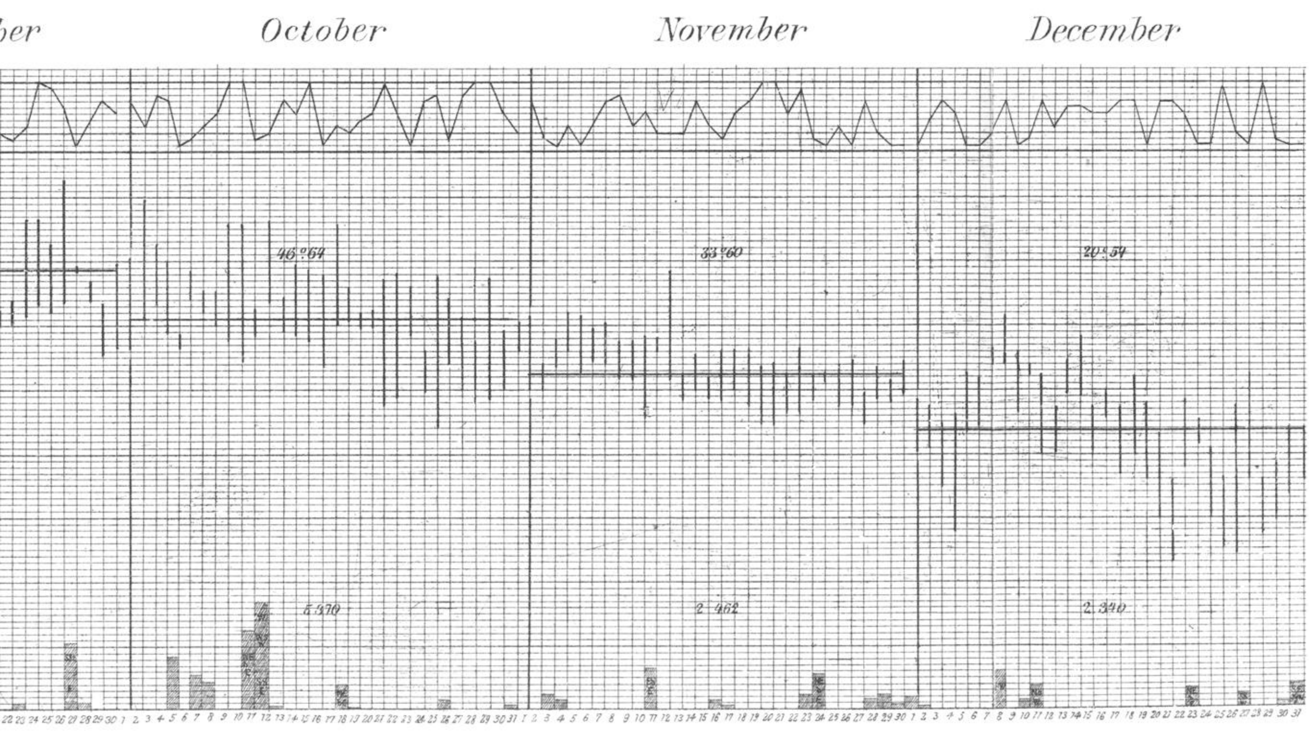

2.428
6.656
11.310


July
August
September
66°.47
69°.29
56°.40
5.732
8.586
11.286


July
August
September
67°.66
66°.84
58°.06
10.188
1.950
4.816


2.079
9.814
4.291


October
November
December
45°48
37°59
6.946
6.360
3.409


October
November
December
46°64
33°60
20°54
5.970
2.462
2.340